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COMBINED STEEL MILL AND MUNICIPAL WASTEWATERS TREATMENT

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COMBINED STEEL MILL
AND
MUNICIPAL WASTEWATERS TREATMENT

BY

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WEIRTON, WEST VIRGINIA 26062

for the

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Abstract

A systems evaluation was made to determine the feasibility and economics of treating selected steel mill and sanitary wastewaters in a municipal sewage treatment plant. The project was Phase I of a three phase program to demonstrate that industries and municipalities through cooperative action can combine their wastewaters and attain their individual treatment goals in an efficient and economical manner.

Detailed field work was carried out at the steel plant and the total sewage plant treatment system. Selected steel plant wastes were combined with municipal wastes and evaluated in both batch and continuous treatability bench scale studies.

The investigation revealed that it is technically and economically feasible to co-treat selected steel plant wastes with municipal wastewaters. A demonstration plant would further develop the specific operating procedures such as sludge concentration control, pH control, and rates of waste additions so that the process scheme could be routinely implemented in similar situations.

This report was submitted in fulfillment of Project Number 12010 DTQ under the partial sponsorship of the Industrial Pollution Control Section of the Environmental Protection Agency.

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Section I

Conclusions

The investigation conducted on the combined treatment of steel mill wastes and municipal wastewater has developed the following conclusions:

1. A totally integrated steel plant generates immense volumes of wastewaters in the varied processes that ultimately lead to the production of steel. Economics and logistic factors concluded that approximately 3.3 mgd wastes from the steel mill could be handled at the Weirton Sewage Treatment Plant. These considerations limit the application of treatment schemes which otherwise would require additional sewer construction or would necessitate hauling of steel plant wastes. A more detailed economic study on in-plant sewer construction, holding tank capacity, equalization basins, and metering of wastes to the main sewer would be most beneficial for a total overall project evaluation. Excessive costs would most certainly curtail more severely the volume of wastes that could be handled from an older existing steel plant.

2. Laboratory bench-scale tests showed that combined coke plant wastes and a limited volume of other steel mill wastes could be treated with municipal sewage provided that additional organic matter was added and that pH control was maintained. The effluent from the Palm Oil Recovery Treatment Plant was shown to be an adequate source of additional organic matter. Fume scrubber wastes were utilized to provide adequate pH control. The treatment studies indicated a decrease in BOD removal in the laboratory bench scale continuous units with time which was attributable to loss of absorptive capacity of the sludge and/or toxicity factors. This condition would necessitate either increased rate of sludge blowdown or separate reaeration of sludge in the treatment process. The need for phosphorus in the treatment scheme can be obtained from tin mill alkaline cleaning wastes.

3. The following waste streams can be treated in the sewage plant within the hydraulic limitations of the existing sewer system:

a. Ammonia still waste
b. Final cooling tower bleedoff
c. Benzol sump

d. Benzol cooling tower bleedoff
e. Absorber barometric condenser waters
f. Pickle line fume scrubber waste
g. Palm oil recovery effluent
h. Effluent from chrome reduction at tin mill and galvanizing lines
i. Tank overflows from the cleaning section of the galvanizing lines
j. Tin mill cleaning lines alkaline solutions
k. Weirlite mill effluent

4. Recirculation and reuse schemes have been determined to be feasible for the following processes with a net reduction in effluent volume.

a. Blast furnace
b. Hot strip
c. Blooming - structural mills
d. Basic oxygen plant
e. Weirlite mills

On the basis of daily water use of 225 mgd and ingot capacity of 3.6 million tons per year, the water use is 22,800 gallons per ingot ton which is considerably less than the widely reported industry average of 40,000 gallons per ingot ton. With the adoption of the forementioned minimum water reuse schemes, the plant water use would be reduced to 16,800 gallons per ingot ton, which is a 26% reduction over the present water use values.

5. With the reuse and treatment systems proposed herein, the proposed lagoon at "C" sewer system, and the proposed co-treatment at the municipal plant, adequate waste treatment will be provided.

Section II

Recommendations

The recommendations made here are on the basis that pending a successful economic evaluation a full scale demonstration plant be implemented at the earliest possible time and that any expenditures made should result in realizable overall waste treatment improvements.

1. It is recommended that providing a justification of in-plant economics a 4.5 mgd activated sludge unit with reaeration of sludge be installed at the Weirton Sewage Treatment Plant. Although approximately 3.3 mgd of steel plant wastes can be handled in the city sewers and at the sewage treatment plant, costs for in-plant sewers and related facilities should be evaluated independently by the steel plant. In addition to internal piping changes, a similar evaluation should be conducted on the merits of providing increased holding capacity through the use of basins or tanks. Whereas a modular type demonstration plant would be the best approach technically, in the interest of time tables facing the city of Weirton, there is substantial merit in the present study after a consideration of the economics to proceed with a full scale demonstration plant. The following waste streams are recommended for the combined treatment plant:

a. Ammonia still waste
b. Benzol sump overflow
c. Final cooler bleedoff
d. Absorber barometric condenser waters
e. Benzol cooling tower bleedoff
f. Tin mill cleaning lines alkaline wastes
g. Weirlite mill wastes
h. Concentrated tin mill chromic wastes after pretreatment
i. Palm oil recovery plant effluent
j. Pickling lines fume scrubber waste
k. Tank overflows from the cleaning section of the galvanizing lines

It is readily apparent that the greatest volume of wastes considered for co-treatment emanate from the coke plant. However, in utilizing these main waste streams, the major coke plant pollution potential would be greatly minimized. If one or several of these waste streams were not included for the treatment scheme, then a pollution potential would still exist at the coke plant. Although the flow from the absorber barometric condenser constitutes the major portion of the waste volume, it has been included due to the waste load it contributes in the overall coke plant total. The bleed from the benzol cooling tower has been included as a safety precaution. The waste load contains no phenol or cyanides, but in the event that a tube should rupture, the waste stream would contain a significant pollution load which would already be tied into the treatment plant.

2. It is further recommended that the following schemes be implemented to further reduce waste volumes:

a. Polyelectrolytes were shown to produce an improved efficiency at the blast furnace. Therefore, the use of polyelectrolytes should be considered in an emergency situation or when the thickener effluent needs improvement to meet more stringent water quality standards.

b. Reuse of water at the blast furnace.

c. Study of water uses at the boiler and power house in an effort to reduce waste volume.

d. Diversion of the structural mill wastewaters through the present splitter box and then discharge of a significant portion of the flow through the present hot strip mill scale pit. An oil skimmer should also be installed at this scale pit. Studies should also be continued toward the use of more sophisticated filtration equipment.

e. An in depth study of water conservation and reuse should be undertaken in the tin mill. There appears to be an excessive amount of costly demineralized water that is wasted to the sewer.

f. Installation of a water reuse system at the hot strip with a minimum of at least the finish stand wastewaters to be diverted for flume flushing on the roughing stands.

g. Further investigate methods for the disposal of waste pickle liquors to reduce present neutralization costs.

h. Further the investigation of the economics of polyelectrolytes versus magnetic flocculation, or combination of both for optimization of operating costs at B.O.P. thickener.

i. Waters from the gas cleaning system platform at the B.O.P. should be sent back to the dust system thickeners.

j. A study should be made on the chemical treatment costs at the coal washer waste treatment facilities.

3. The proposed plant should have built-in flexibility to readily make modifications to basic system components to encompass the latitude of wastes that can be treated. The plant should be operated to study various ratios of combined steel plant and municipal wastes. The secondary unit should be designed for greater flexibility in retention times and air rates to provide an evaluation of synergistic effects in primary plant and biological improvements in secondary plant.

4. The combined treatment plant should be designed to provide greater than a 90% removal of BOD and suspended solids. Although design of the demonstration plant is not included in this phase of the project, based on the treatability evaluation and standard sewage plant design, some preliminary design criteria may be established as follows:

a. Primary tanks - surface settling rate <600 GPD/ft^2

b. Aeration tanks - BOD applied loading - 35 Lbs/1000 ft^3
Detention time - 6 hours
Tank depths - 10 to 15 feet
Air requirements - 2 ppm dissolved oxygen
1500 cubic feet air/Lb. BOD

c. Sludge pump capacity - 50% of design flow to optimize mixed liquor suspended solids

d. Final settling tanks - surface settling rate <800 GPD/ft^2

5. Holding tanks should be installed at or near the point of origin for the retention of required industrial wastes. Where discharge is intermittent metering pumps should be provided for the addition of certain industrial wastes at uniform rates over 24 hour periods. Control of pH should be maintained in the sewer system as close as possible to the plant to enable proper changes to be made rapidly.

6. Adequate provisions should be made for test equipment at the sewage plant to control and evaluate process changes. This program in itself would be of great benefit in evaluating test equipment and assisting in the selection of proper instrumentation in future plants of this type.

Section III

Introduction

The primary objective of Project No. 12010 DTQ is to conduct a study to develop and demonstrate the treatability of water borne wastes from an integrated steel mill with municipal wastes. In addition to producing a satisfactory effluent in accordance with established water quality criteria, the cost of the joint treatment process must be evaluated by the city and the steel company. The following considerations were important in the decision to undertake the study of a joint municipal - industrial treatment system.

1. Lower overall construction, maintenance and operating costs.
2. Better overall effective treatment and control of wastewater.
3. One centralized plant to provide optimum land use.
4. Centralized and more effective supervision.

Weirton Steel Division, National Steel Corporation, where the study was conducted, is located on the east bank of the Ohio River at the confluence of Harmon Creek in the town of Weirton, West Virginia, approximately 62 miles down the Ohio River from Pittsburgh, Pennsylvania.

The plant is located on a 350 acre site running generally from north to south in an arc-shaped valley, intersecting the river at the northern end. Located here are the river docks, coal storage, ore storage, coke oven batteries, and the tin mill facilities. The continuous casting and basic oxygen facilities are situated at the center of the crescent, separated from the iron making complex by a highway. The lower extent of the arc contains the hot strip mill, cold mills, finishing and shipping facilities. (See Figure 1)

Over the years Weirton has devoted much time and effort to water conservation and wastewater treatment. Most of Weirton's wastes are now being treated in-plant. The company is presently looking at additional methods for treating their wastes. The treatment of wastewaters in a combined treatment plant would be an effective means of meeting the more stringent stream quality criteria now being proposed.

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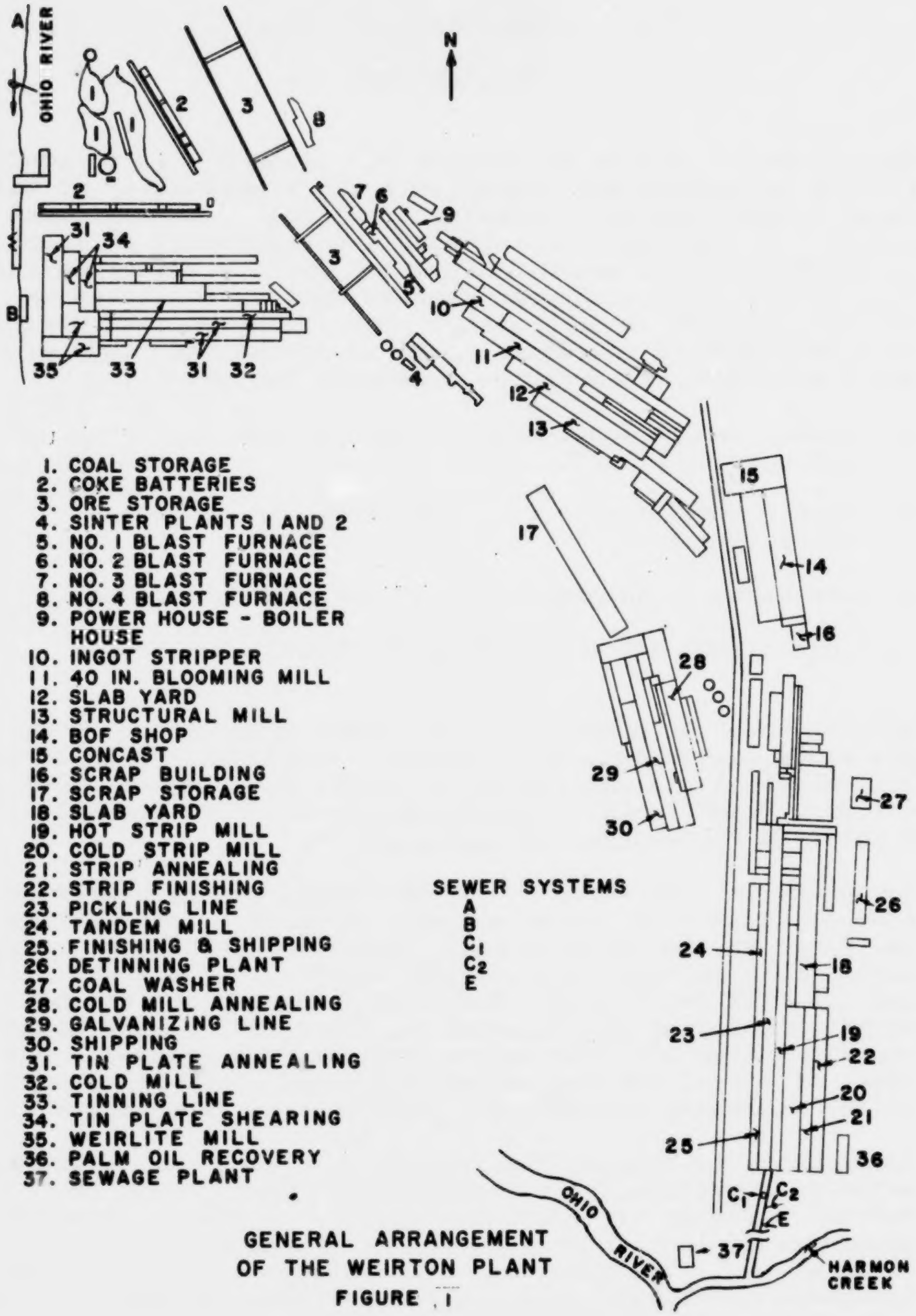


GENERAL ARRANGEMENT
OF THE WEIRTON PLANT
FIGURE 1

This plant is a completely integrated steel mill producing the following line of products: coke, pig iron, steel ingots, blooms, slabs, billets, heavy structural shapes, steel piling, tin mill products (black plate, tin plate-electrolytic, chrome plate electrolytic), sheet and strip (hot-rolled, cold-rolled, hot dipped galvanized, electrolytic galvanized) and coal chemicals produced in their by-product coke ovens.

The plant facilities discharge wastewaters into four (4) major sewer systems lettered alphabetically A, B, C, and E.

Systems A and B discharge to the Ohio River, whereas C and E drain into Harmon Creek and then to the Ohio River.

The city of Weirton operates a sewage treatment plant under the direction of the sanitary board with the mayor as chairman. The plant employs a superintendent and fourteen (14) full-time employees.

The primary sewage treatment plant is designed for a flow of four million gallons per day. The average flow rate through the plant is 1.25 million gallons per day. The plant consists of the following major facilities:

1. Grit chamber
2. Comminutor
3. Raw sewage wet well
4. Raw sewage pumps
5. Preaeration tanks
6. Primary sedimentation tanks
7. Chlorine contact tank
8. Digestors
9. Vacuum filter
10. Control building - office & laboratory

The plant discharges a chlorinated effluent with a 50% reduction in suspended solids and a 40% reduction in BOD. The initial cost of the total plant and sewer system was $5,500,000. The sanitary board has received orders to provide secondary treatment by December, 1975.

The study phase of the project was divided into five (5) distinct tasks, namely:

1. Mill Field Work
2. Sewage Plant Field Work
3. Sanitary Sewer System Field Work
4. Laboratory Studies

5. Evaluation

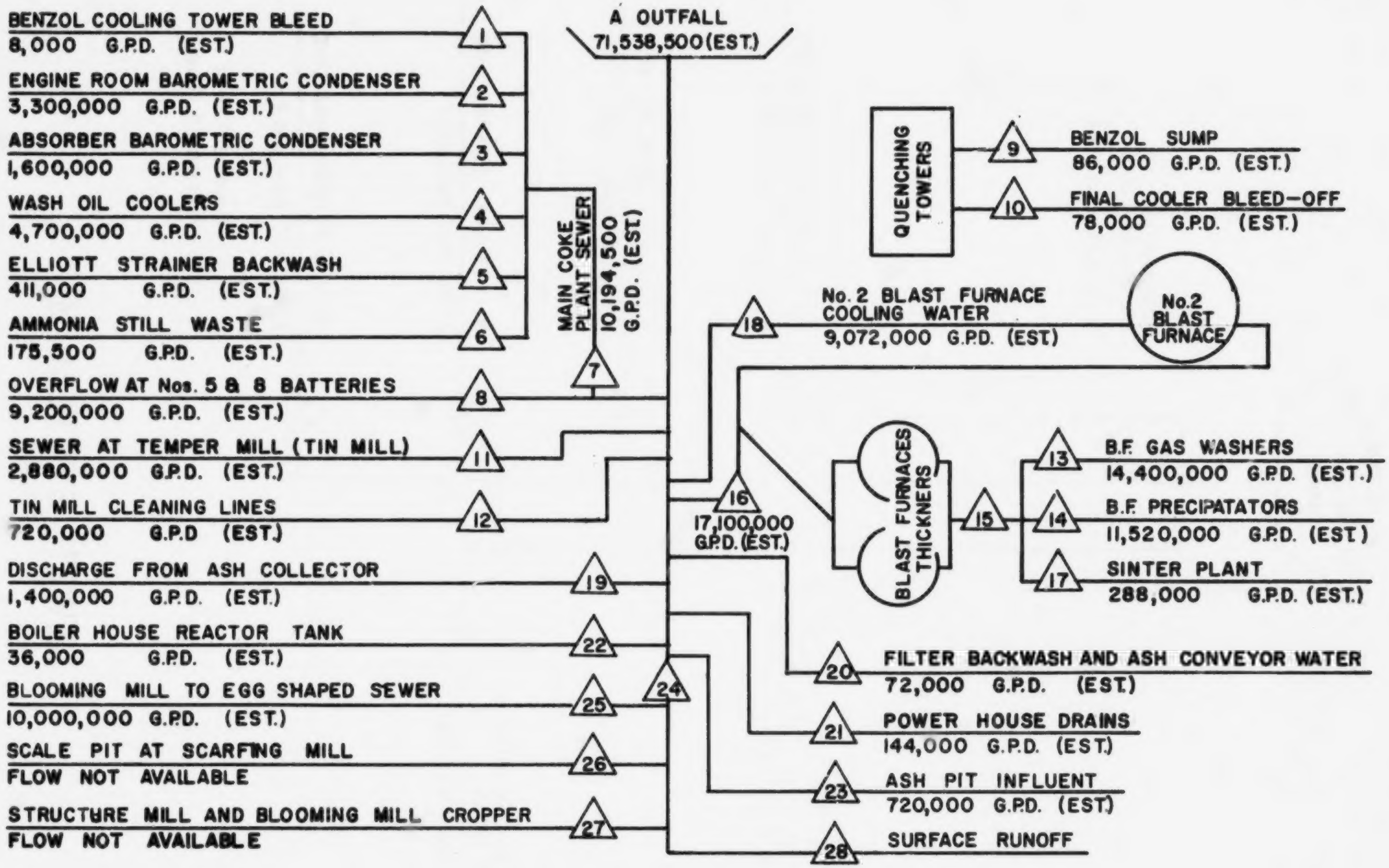
Task I - Mill field work

This task was devoted to obtaining the basic plant wastewater data and other pertinent information in respect to the overall plant operations. For better efficiency in organization of the mill data the plant was subdivided into four (4) main sewer systems:

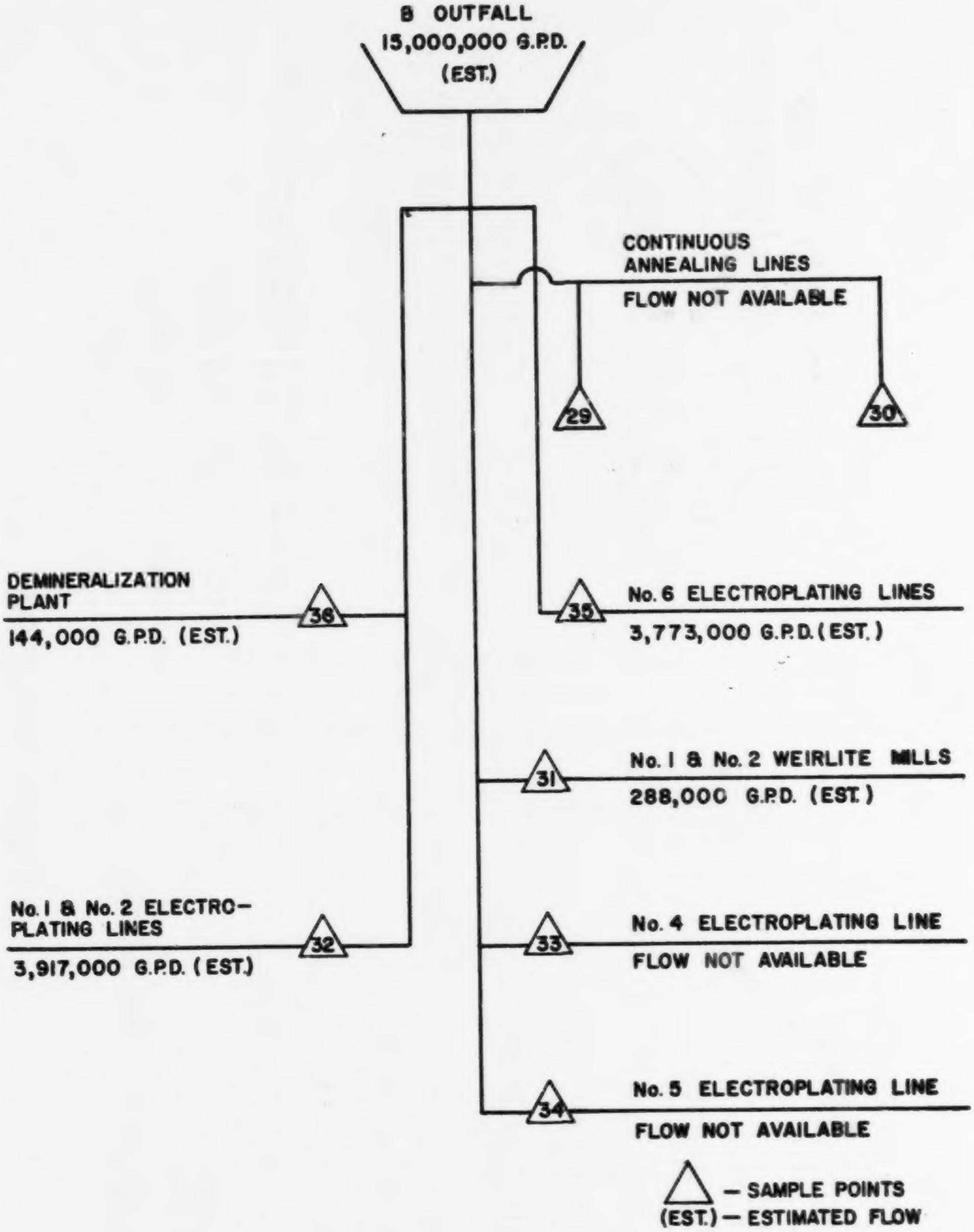
1. Sewer system A (See Figure 2)
    - a. Coke plant
    - b. Temper mill
    - c. Tin mill cleaning lines
    - d. Blast furnace sinter plant
    - e. Blooming mill - Structural mill
2. Sewer system B (See Figure 3)
    - a. Continuous anneal lines
    - b. Weirlite mills
    - c. Electroplating lines
    - d. Demineralizer plant
3. Sewer system C (See Figure 4)
    - a. Tandem mills
    - b. Palm oil recovery
    - c. Hot strip mill
    - d. Pickling lines
    - e. Galvanizing dept. (Sheet mill)
    - f. Diesel and car repair shop
    - g. Structural mill
4. Sewer system E (See Figure 5)
    - a. Basic oxygen plant
    - b. Continuous caster
    - c. Detinning plant
    - d. Coal washer
    - e. Galvanizing operations (Sheet mill)

Subtasks in the mill field work included:

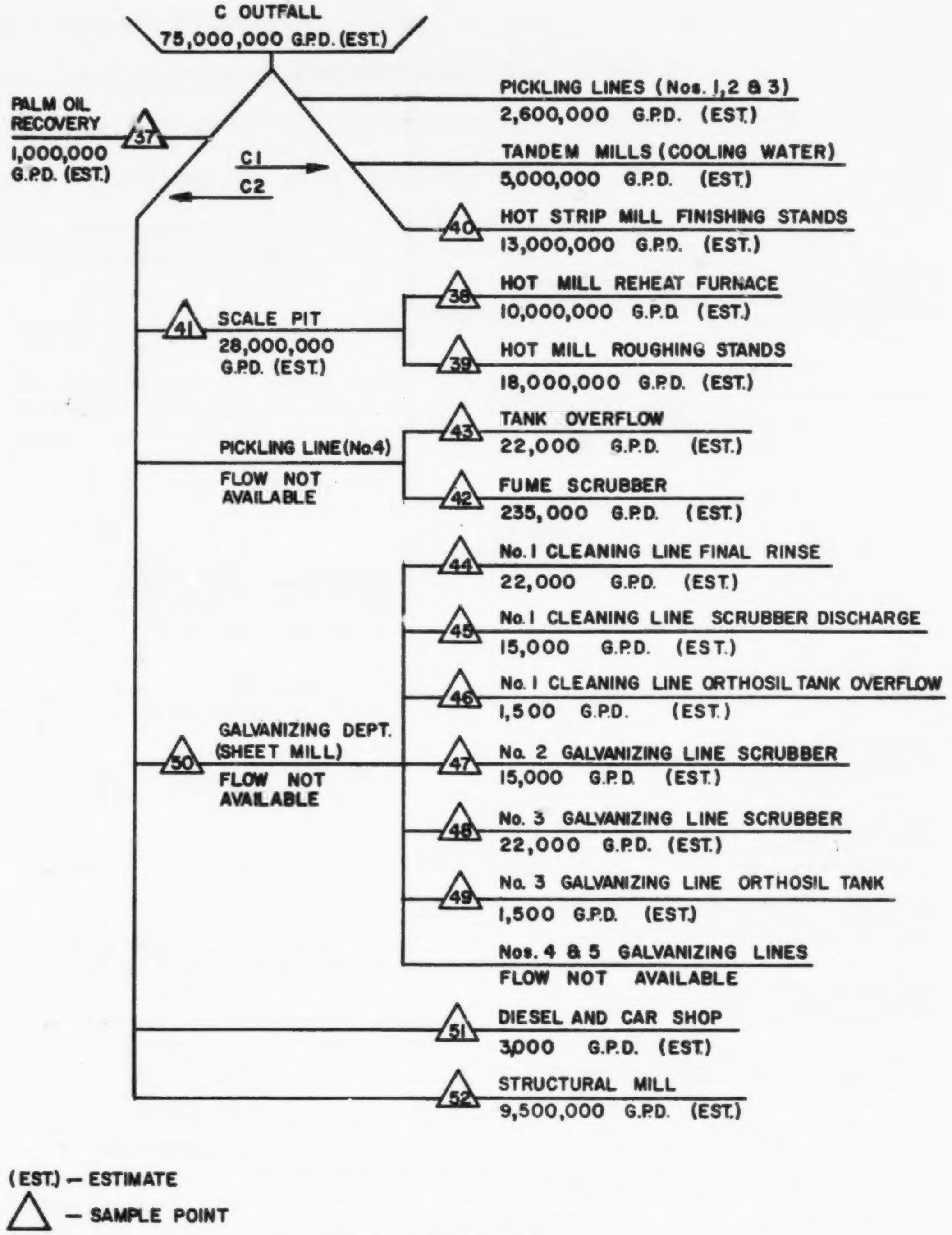
a. Sampling and analytical work at key points in the respective process area.



SEWER SYSTEM A
FIGURE 2

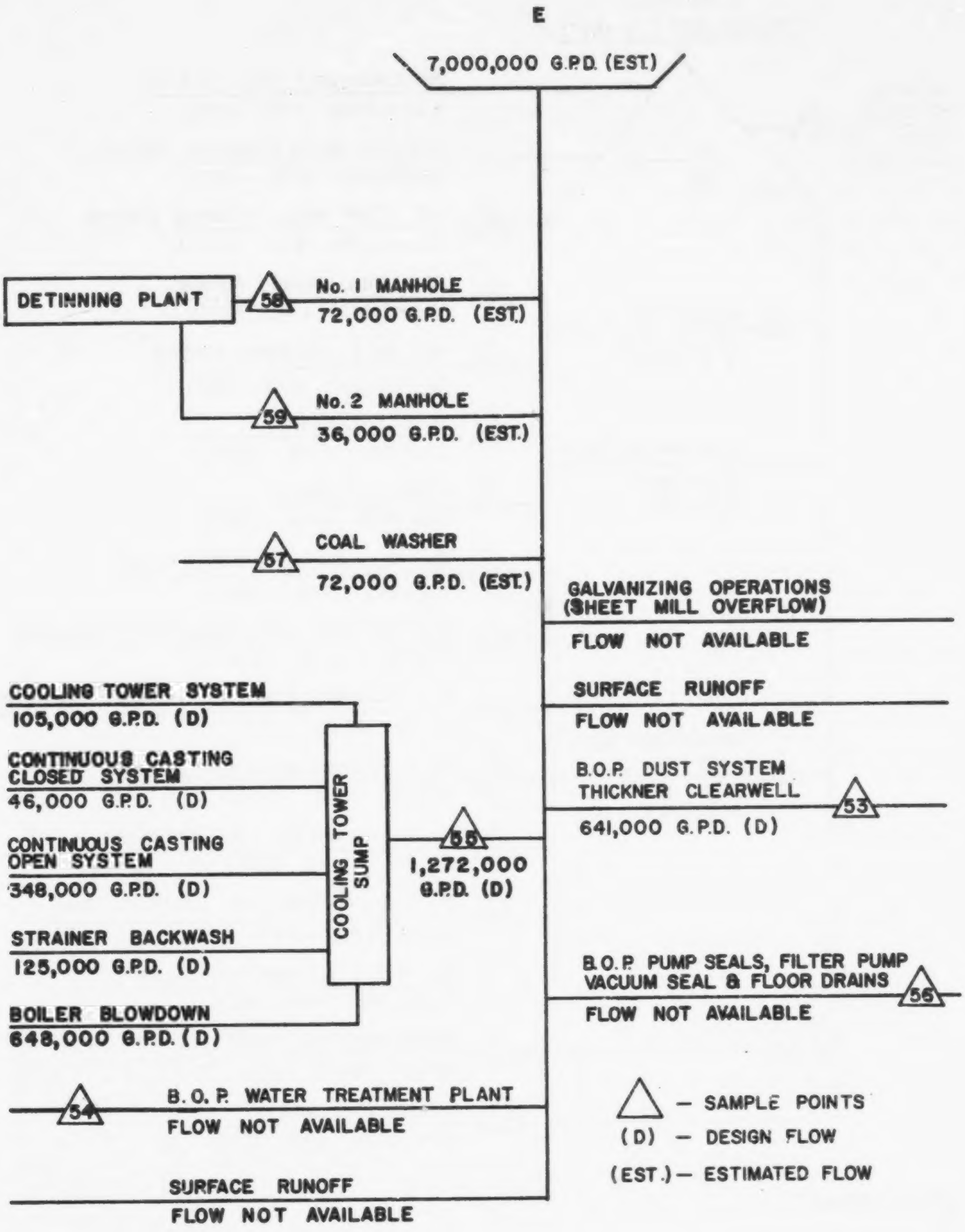


SEWER SYSTEM B
FIGURE 3



SEWER SYSTEM C

FIGURE 4



SEWER SYSTEM E

FIGURE 5

b. Study of the plant sewers

c. Acquisition of process operating data

d. Evaluation of present waste treatment facilities

e. Investigation of water conservation

f. Appraisal of wastes to be included in combined treatment scheme.

Task II - Sewage plant field work

The objective of this task was to evaluate the present municipal sewage plant and review the various processes that could be utilized to upgrade the existing plant to meet the future secondary treatment requirements of the state.

Subtasks in the sewage plant field work included:

a. Evaluate the respective units of the present plant as to their overall treatment capabilities and efficiencies

b. Review alternatives for secondary treatment

c. Determine volume of steel plant wastes that could be handled at municipal plant

d. Appraise effect on river if combined wastes are treated at sewage plant

Task III - Sewer system field work

a. Determination of the hydraulic adequacy of the portion of the city of Weirton sewer system which relates to the transport of steel plant wastewaters.

b. Consideration of alternatives in transporting and treating the municipal and industrial wastewaters.

Task IV - Laboratory and bench scale studies

This task was concerned with the various laboratory studies run on individual waste streams as well as with the alternatives for a combined treatment process.

Subtasks included in the laboratory studies were:

a. Operation of batch and continuous bench scale plants

b. Investigation of waste treatment schemes for individual process wastes.

Task V - Evaluation

The purpose of this task was to compile the data from the other four (4) tasks and assess the overall feasibility of a combined industrial and municipal waste treatment system.

Subtasks in the evaluation included:

a. Evaluation of Tasks I - IV

b. Recommendations for implementing conclusions developed in plant survey

c. Recommendations for upgrading municipal sewage plant

d. Recommendations for modular - pilot plant demonstration studies

e. Preparation of a final report

The mill survey was conducted on the four main sewer systems:

"A", "B", "C", and "E", Each of these sewer systems is described schematically in Figures 2 through 5 which show the various mill operations associated with the respective systems. Figure 1 shows the general arrangement of the mill in respect to the city of Weirton sewage treatment plant.

Both grab and continuous sampling techniques were used throughout the project. The continuous samplers were of two types; 1) single composite and 2) sequential. Flows were measured using standard techniques, namely; 1) bucket and stop watch, 2) weirs, 3) salt concentration, 4) depth and velocity of flow in sewers and 5) flow from open end pipe. Due to the inaccessibility of most sewers, the majority of the flows were obtained by the salt concentration technique. A brief description of this method follows:

A known strength of salt solution was added at a constant measured rate of flow to the sewer. Chlorides were then determined at a lower point in the sewer after the salt had been well mixed in the flow of the sewer. A blank determination was made first. This was done by taking 5 or 6 samples at five minute intervals before any salt solution was added and measuring the chlorides present. When salt is added to the waste flow at a known continuous rate in pounds and the resulting salt concentration is measured, the flow can be determined by the formula:

$$\frac{\text{lbs per hour of salt added} \times 2000}{(\text{ppm NaCl measured} - \text{ppm NaCl in blank})} = \text{gallons per minute}$$

Section IV

Sewer System A

Wastewaters that discharge to sewer system "A" originate from the following areas:

Coke plant
Temper mill
Tin mill cleaning lines
Blast furnace - Sinter plant
Power house and boiler house
Blooming mill - Structural mill

A schematic of sewer system "A" is shown in Figure 2. Sampling points and flow rates for the various wastewater streams are indicated on the schematic.

Coke Plant

In a totally integrated steel plant the steelmaking process indirectly begins at the coke plant. Here coal is delivered to the plant site and converted to coke. This is the first in the many and varied processes that contribute to the ultimate production of the steel product.

At this point batteries of coke ovens are grouped in two strings of three batteries each. All ovens are of the low differential underjet type. Four batteries are heated with blast furnace and coke oven gases, the other two use coke oven gas only.

The coal is converted to coke in narrow rectangular silica brick ovens arranged side by side in batteries. Heat is applied by burning gas in flues located between the walls of adjacent ovens. Modern ovens are about 40 feet long, 8 to 15 feet high and 14 to 24 inches wide, with a capacity of 15 to 20 tons of coal per charge. The ovens are heated by burning either coke oven or blast furnace gas. For ease in removing the coke, ovens are tapered 2 to 4 inches from the pusher side to the coking side.

Coal is charged through openings in the top of the ovens by means of hopper bottom cars that travel on tracks located on top of each battery. The ovens are then sealed and the coking process beings. The coal is heated in the absence of air to a temperature above which the volatile matter is driven off, leaving a residue, or coke, which is principally

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carbon. The coking time depends on the oven temperature and width, but the general average is about one hour per inch of oven width. Average coking time is about 17 hours.

Upon completion of the coking cycle, the coke is pushed from the oven into a "hot" car. The pushing operation requires about a minute, and the car is now run to the quench tower, where the incandescent coke is sprayed with a large flow of water approximating 4,000 gpm. The coke is drained for a few seconds and then dumped onto a wharf for hose quenching of local hot spots. The coke is then transferred to a screening operation and then depending on its size either delivered by belt conveyor the blast furnace, used in the sinter plant, boiler house, or sold for stoker fuel.

Raw coke oven gas is cooled by spray type coolers, cleaned by tar electrostatic precipitators, and scrubbed with sulfuric acid to strip the ammonia from the gas.

In the by-produce section tar, oil, ammonia, and phenol are recovered through systems which include various type coolers, exhausters, gas scrubbers, vacuum type ammonia scrubbers, and centrifugal extraction.

Coke plant wastewaters generally have received more than their share of publicity because of concern about taste and odor problems in municipal water supplies. There are several processes in the coking operation that are potential sources of pollution. Included are the quenching station, effluent from the ammonia still, final cooler bleed, barometric condenser discharges, wash oil coolers, and bleed off from the benzol cooling tower. Coke plant waste streams generally contain phenol, cyanide, ammonia, oil, sulfides, sulfates, and chlorides.

The chief use of water in coke making is to quench the hot coke after it is pushed from the ovens. In addition, considerable amounts of water are used in the recovery of coal chemicals, steam generation for heating stills, cooling in heat exchangers and condensers, and washing of crystalline products.

Field work was conducted on the following waste streams in the coke plant process:

⚠ Benzol cooling tower bleed

The benzol cooling tower constitutes an indirect cooling operation. Wastes are in the nature of coil leaks and water that is bled off to control the total hardness.

△2 Engine room barometric condenser

This stream constitutes the large volume of water that is used to condense the steam from the coke oven gas booster turbines.

△3 Absorbed barometric condenser

The absorber barometric condenser is one of the integral components in the process for the recovery of ammonia. In the process the gas is passed through a spray type absorber over which is circulated a sulfuric acid solution nearly saturated with ammonium sulfate. The solution then leaves the absorber and is delivered to the solution circulating system of a crystallizer. The barometric condenser, through vacuum evaporation in a combined cooling and concentrating effect, produces the crystallization which takes place.

△4 Wash oil coolers

Wash oil is cooled by the application of water over cooling coils; however, the water is not in direct contact with the wash oil.

△5 Elliott Strainer backwash

The Elliott Strainer is a basket type strainer that filters incoming raw river water to the coke plant. Wastewater is that which is used to backwash water screens.

△6 Raw ammonia liquor - Still waste

Initial cooling of the gases takes place in the collecting main where they are in contact with sprays of flushing liquor, which has previously been condensed from the gases. This liquor is composed of moisture in the coal and the water produced by decomposition of the coal. From the collecting main the gases then pass through primary coolers. The flushing liquor and the primary cooler condensate drain to decanters for separation of tar and liquid. This liquor condensed from the gases is referred to as ammonia liquor. The raw ammonia liquor is then discharged to the phenol recovery plant. After the phenol-extraction process the ammonia liquor passes to the ammonia still. The liquor resulting from steam stripping ammonia from the raw ammonia liquor is called still waste. The composition of ammonia still wastes is related directly to the volatility of the coal, coking temperature, and to unit design.

7 Coke plant main sewer

This waste stream is a combination of the previous six waste streams (1 through 6).

8 Overflow at 5 and 8 battery

This waste stream constitutes the water that is used for cooling at the ammonia liquor coolers. This is non contact water that passes through a shell and tube type heat exchanges.

9 Benzol sump

Condensed steam from the stripping operations and cooling water constitutes the bulk of liquid discharged to the sump. At this plant these wastes are used for quenching.

10 Final cooler bleedoff

The first step in the recovery of light oil by adsorption in a liquid medium is that of cooling the gas leaving the saturators by direct contact with water in a tower scrubber called a final cooler. The name is derived from the fact that the gas here is given its final cooling in the coal-chemical processing. This is necessary to remove naphthalene from the gas and also cool the gas prior to its admission to the wash oil scrubbers. The cooling water comes in direct contact with the gas from the ovens. This water is recirculated but the overflow constitutes a pollutional waste. This water is also utilized for coke quenching.

Analyses run on the coke plant waste streams included:

1. pH
2. Phenol
3. Cyanide
4. 5 day BOD
5. COD
6. TOC
7. Oil
8. Chlorides
9. Suspended solids
10. Ammonia
11. Sulfates

Approximately 600 samples were analyzed from the various sampling locations at the coke plant. Analytical data are given in Tables 1 through 10 .

TABLE △1
BENZOL COOLING TOWER
FLOW 8,000 GPD

	High	Low ppm	Average	Lbs/Ton
pH	7.90	7.30	7.50	
Phenol	0.45	0.02	0.17	.00001
Cyanide	0.11	0.03	0.08	.000007
Oil	21.50	4.80	10.20	.0009
Sulfates	324.00	132.00	244.00	.0211
Chlorides	325.00	235.00	276.00	.0239
B.O.D.	11.00	8.00	9.60	.0008
C.O.D.	93.30	84.60	89.00	.0077
T.O.C.	27.30	20.50	24.00	.0021

TABLE △2
ENGINE ROOM BAROMETRIC CONDENSER
FLOW 3,300,000 GPD

	High	Low ppm	Average	Lbs/Ton
pH	8.30	6.90	7.30	
Phenol	0.03	0.01	0.02	.00007
Cyanide	0.09	0.01	0.06	.0002
Oil	3.50	1.00	1.90	.0069
B.O.D.	6.00	2.00	4.50	.0162
C.O.D.	100.00	13.00	55.00	.1986
T.O.C.	69.00	22.00	47.00	.1698

TABLE △3
ABSORBER BAROMETRIC CONDENSER
FLOW 1,600,000 GPD

	High	Low ppm	Average	Lbs/Ton
pH	6.8	4.7	6.0	
Phenol	36.5	26.5	30.8	.0767
Cyanide	33.2	14.8	25.8	.0642
Oil	2.0	1.2	1.5	.0037
B.O.D.	41.0	36.0	38.0	.0946
C.O.D.	121.0	6.0	59.0	.1469
T.O.C.	69.0	8.7	43.0	.1072

TABLE 4
WASH OIL COOLERS
FLOW 4,700,000 GPD

	High	Low ppm	Average	Lbs/Ton
pH	7.60	6.90	7.20	
Phenol	0.91	0.12	0.42	.0024
Cyanide	0.11	0.07	0.09	.0005
Oil	8.00	1.71	4.00	.0234
Sulfates	120.00	60.00	93.30	.5459
Chlorides	25.50	22.00	23.30	.1363
B.O.D.	5.00	5.00	5.00	.0292
C.O.D.	16.00	11.00	14.00	.0819
T.O.C.	11.40	8.60	10.00	.0585

TABLE 5
ELLIOTT STRAINER BACKWASH
FLOW 411,000 GPD

	High	Low ppm	Average	Lbs/Ton
pH	7.2	6.6	6.9	
Sulfates	144.0	132.0	138.0	.0704
Chlorides	25.5	23.5	24.5	.0125
Suspended Solids	140.0	4.0	78.0	.0398
Dissolved Solids	340.0	280.0	316.0	.1613

TABLE 6
AMMONIA STILL WASTE
FLOW 175,500 GPD

	High	Low ppm	Average	Lbs/Ton
pH	8.2	5.4	6.2	
Phenol	461.0	84.0	230.0	.0428
Cyanide	280.0	101.0	212.0	.0395
Ammonia	4.3	3.9	4.1	.0008
B.O.D.	-	-	1057.0	.1972
C.O.D.	-	-	2380.0	.4440
T.O.C.	-	-	1192.0	.2224

TABLE 7
MAIN COKE PLANT SEWER
(This Waste Stream is a Combination of Streams 1 - 6)
FLOW 10,194,500 GPD

	High	Low ppm	Average	Lbs/Ton
pH	7.2	5.3	6.2	
Phenol	4.2	1.8	3.5	.0522
Cyanide	7.5	2.2	5.1	.0761
Oil	8.8	3.6	5.5	.0821
Ammonia	73.6	28.5	55.0	.8210
Sulfates	240.0	228.0	234.0	3.4920
Chlorides	135.0	80.0	106.5	1.5890
B.O.D.	8.0	7.0	7.5	.1119
C.O.D.	44.0	41.0	42.5	.6343
T.O.C.	31.0	27.0	29.0	.4328

TABLE 8
OVERFLOW AT 5 & 8 BATTERY
(AMMONIA LIQUOR COOLER OVERFLOW)
FLOW 9,200,000 GPD

	High	Low ppm	Average	Lbs/Ton
pH	7.50	6.40	6.90	
Phenol	35.00	0.06	0.16	.0019
Cyanide	0.08	0.03	0.05	.0006
Oil	6.90	1.70	4.70	.0556
Ammonia	1.95	0.97	1.57	.0186
Chlorides	25.00	22.00	24.00	.2838

TABLE 9
BENZOL SUMP
FLOW 86,000 GPD

	High	Low ppm	Average	Lbs/Ton
pH	7.6	7.4	7.5	
Phenol	316.0	300.0	308.0	.0331
Cyanide	33.8	24.4	28.0	.0030
Oil	95.9	34.0	55.7	.0060
Ammonia	32.5	32.5	32.5	.0035
Chlorides	90.0	80.0	85.0	.0091
B.O.D.	567.0	470.0	514.0	.0552
C.O.D.	1026.0	962.0	996.0	.1070
T.O.C.	477.0	414.0	438.0	.0471

TABLE 10
FINAL COOLER BLEED-OFF
FLOW 78,000 GPD

	High	Low ppm	Average	Lbs/Ton
pH	8.2	7.8	8.0	
Phenol	1384.0	1089.0	1261.0	.1223
Cyanide	146.9	55.0	109.3	.0106
Oil	36.0	3.3	16.5	.0016
Ammonia	553.2	322.2	431.6	.0419
Chlorides	340.0	270.0	300.0	.0291
B.O.D.	2650.0	2490.0	2563.0	.0286
C.O.D.	4952.0	4602.0	4750.0	.4608
T.O.C.	1058.0	1016.0	1041.0	.1010

Recommendations

Because of the fact that coke plant wastes are considered as major steel plant pollutants and since the wastes are amenable to biological treatment, a major portion of the treatability studies were coke plant oriented. The laboratory study section of the report outlines the waste streams investigated and significant results obtained in combinations with municipal sewage.

It is recommended that the following waste streams from the coke plant be included as part of the flow for the proposed municipal - industrial biological treatment system.

1. Benzol cooling tower bleedoff △1
2. Absorber barometric condenser waste △3
3. Ammonia still waste △6
4. Benzol sump waste stream △9
5. Final cooler bleedoff △10

Temper Mill

The main purpose of the temper mill is to develop the proper stiffness or temper by cold working the steel in controlled amounts. In addition, temper rolling tends to improve the flatness of annealed strip to develop desired mechanical properties and to impart the desired surface finish to the finished product.

At the temper mill lubricating oils are discharged to a holding tank and hauled away by an outside contractor. Water used for indirect cooling is discharged to the "A" system. Analytical data for this waste stream is shown in Table △11.

TABLE 11
SEWER AT TEMPER MILL AREA
FLOW 2,880,000 GPD

	High	Low ppm	Average
pH	9.4	8.6	9.10
Pht. Alkalinity	140.0	6.0	69.90
M.O. Alkalinity	200.0	32.0	95.60
Hexavalent Chrome	0.1	0	0.03
Total Chrome	0.2	0.1	0.10
Suspended Solids	40.0	25.0	33.00
Oils	57.6	13.9	30.80

Tin Mill Cleaning Lines

The primary function of the tin mill cleaning lines is to prepare the strip for tinning. Here the lubricant is removed to produce a bright clean strip. At this department cleaning is performed using alkaline detergent solutions.

The department has two cleaning lines which contain the same units to remove all oil and dirt from coils. The steel moves at a rate of up to 1,800 FPM through a dip tank of sodium orthosilicate solution; a scrubber with water sprays and revolving brushes; an electrolytic tank of sodium orthosilicate solution; another scrubber; a hot water rinse tank with final wringer roller; and a hot air dryer. After drying, the strip moves through a free loop, a drag tension unit, and to the winding reel.

At the cleaning lines, water use is primarily for solution makeup, spray scrubber water, and rinsing operations. Sampling at each individual operation was not feasible; therefore, the combined flow of the two lines was sampled and considered representative of the cleaning line waste effluent.

Analytical data for this waste stream are shown in Table 12 . The product mix is variable and hence sampling cannot be tied to specific production figures. Therefore, the waste load is not calculated in pounds per ton.

TABLE 12
TIN MILL CLEANING LINES - MAIN SEWER
FLOW 720,000 GPD

	High	Low ppm	Average
pH	12.1	11.4	11.8
Pht. Alkalinity	1140.0	260.0	769.7
M.O. Alkalinity	1340.0	500.0	873.3
Hexavalent Chrome	34.0	0.9	30.7
Total Chrome	70.0	20.0	46.6
Suspended Solids	1652.0	420.0	1026.0
Silicon	353.0	96.3	183.1

Recommendations

Tin mill alkaline cleaning solutions were utilized in the laboratory treatability studies as an excellent source of phosphorus and also for pH control. Therefore, it is recommended that this waste be considered at the combined treatment plant as needed for a source of alkalinity and phosphorus.

Blast Furnace - Sinter Plant

The molten iron for the steelmaking operations is normally produced in a blast furnace. The blast furnace process consists of charging coke, iron ore, and limestone into the top of the furnace, and blowing heated air or oxygen into the bottom. Approximately one and one half tons of ore, one half ton of limestone, and one ton of coke produce one ton of iron, one-half ton of slag, and five tons of blast furnace gas. The molten iron is drained from the bottom of the furnace by drilling a hole in a clay plug near the bottom and allowing the liquid iron and slag to flow out. The slag being lighter in weight floats on top of the iron and is diverted to slag ladles.

As with most of the steel mill operations, the blast furnace has several supplementary components that are vital to the total operation. These include (1) the stoves in which the air (blast) is preheated, (2) dry dust catchers in which the bulk of the flue dust is recovered, (3) primary wet cleaners in which most of the remaining flue dust is removed by water washinq and (4) seocndary cleaners such as electrostatic precipitators and disintegrators for more efficient gas cleaning.

Four blast furnaces and two sinter plants comprise the iron production facilities at Weirton. All basic iron is used at the BOF shop.

Blast furnaces use large volumes of water principally for cooling the various parts of the furnace and its auxiliaries. In addition to the water used for cooling, the blast furnace uses a considerable amount of water for cleaning flue gas, both from the standpoint of washing exit gases and also for providing a cleaner gas for reuse. The principal contaminants in blast furnace gas washer water are suspended solids but the water may contain significant amounts of cyanide, phenol, and ammonia.

There are essentially three basic sources of water for the blast furnace. They include (1) recirculated water from the thickener which amounts to about 6,300 gpm which is used for cooling in No. 2 blast furnace, (2) water from the power house hot well which amounts to approximately 30,000 gpm which is used for cooling the other three blast furnaces in addition to gas washing and electrostatic gas cleaning on all four furnaces, and (3) approximately 200 gpm of river water used at the sinter plant which is used for cleaning air exhaust of sinter plant fines on Rotoclones.

The gas cleaning operation is the major source of water pollutants in the blast furnace area. Since the blast furnace dust is handled more easily and economically in the dry state, the gas passes through a dry dust catcher to remove a large portion of the flue dust blown over from the furnace. The exit gas then enters a venturi washer which contains two sets of water sprays in which the gas is further cleaned to a dust content of 0.05 grains per cubic foot. The gas then passes to a cooling tower where its temperature is lowered by passing through water sprays. The cooled gas then enters secondary cleaners called disintegrators that consist of a casing in which is mounted a rotating squirrel cage. Vanes mounted on the cage head reduce the pressure drop through the machine and force the incoming gas through the rotating bars, upon which water is sprayed, to the center of the cage. The gas then passes to electrostatic gas cleaners in which an electrostatic field is maintained. The unit collecting electrode is a vertical tube in which a thin film of water flows over the inside edge of each tube washing it free of the dust that is deposited thereon.

All these dirty gas cleaning waters are conducted to the Dorr Thickener. The typical thickener consists of a circular, reinforced concrete tank which contains several compartments in which one or several arms revolve. Water enters at the center of the thickener and exits over a continuous weir which follows the circumference of the compartment. The thickener solids are delivered to a filter located at the nearby sinter plant. The filtrate returns to the thickener and the cake is used at the sinter plant. The primary function is to agglomerate the flue dust and filter cake into a product more acceptable for recharge into the furnace. Its secondary function is to beneficiate some of the finely divided ore.

Before the finer particles of ore and flue dust can be used beneficially they must be converted to a lump form. Sintering is the most commonly used method today to accomplish this end. There are several reasons why this must be done: (1) finer sizes compact in the furnace and do not permit proper gas passage, (2) minute particles more readily become airborne in the furnace and will pass out of the furnace as flue dust in the exit gases creating bad furnace operation and excessive dust loss and (3) agglomerating improves the ore both physically and chemically.

In making sinter, ore fines are mixed with fine coke breeze for fuel and fine limestone. The material is then processed so that the mass will not be too compact, and discharged on to traveling grates and ignited. Air is drawn through thin layers forming a clinker. After the burning cycle the clinker passes to an operation that breaks the sinter into pieces. The larger pieces are transferred by belt conveyor to the blast furnace, and the smaller fines remain at the sinter plant and are returned to the original mix for resintering.

Uses of water in a sinter plant are as additions for controlling the moisture content of the mix, for dust control, and for cooling sinter.

Field work was performed at the following locations in the blast furnace - sinter plant area:

△13 Four gas washers

△14 Eight precipitators

△15 Thickener influent

△16 Thickener effluent

△17 Sinter plant sewer to thickener

△18 Cooling water from No. 2 blast furnace

Approximately 600 samples were taken on these waste streams and analyzed for the following: (See Figure 2).

1. pH
2. Suspended Solids
3. Phenol
4. Cyanide
5. Chlorides
6. Total Iron
7. Phosphates
8. Alkalinity
9. Dissolved Solids

TABLE △13
GAS WASHERS
FLOW 14,400,000 GPD

	High	Low ppm	Average	Lbs/Ton
pH	7.6	6.6	7.1	
Temperature	120°F	98°F	109°F	
Suspended Solids	1247.0	104.0	316.0	5.15
Phenol	0.93	0.01	0.41	0.0067
Cyanide	16.0	3.35	2.60	0.042
Chlorides	51.5	40.00	45.60	0.2229

TABLE 14
PRECIPITATORS
FLOW 11,520,000 GPD

	High	Low ppm	Average	Lbs/Ton
pH	8.0	6.2	6.9	
Temperature	106°F	88°F	96°F	
Suspended Solids	371.0	6.0	81.0	1.050
Phenol	0.07	0.01	0.038	0.005
Cyanide	22.0	1.20	9.9	0.129

TABLE 15
THICKENER INFLUENT
FLOW 26,210,000 GPD

	High	Low ppm	Average	Lbs/Ton
pH	7.4	7.3	7.3	
Suspended Solids	1510.00	482.50	1239.50	40.400
Phenol	1.16	0.47	0.66	0.022
Cyanide	12.63	7.38	10.66	0.348
Chlorides	60.00	52.50	56.25	1.800

TABLE 16
THICKENER EFFLUENT TO "A" SEWER
FLOW 17,100,000 GPD

	High	Low ppm	Average	Lbs/Ton
pH	7.8	7.1	7.5	
Suspended Solids	125.00	34.00	52.00	1.2
Phenol	0.04	0.02	0.03	0.0006
Cyanide	9.20	3.20	5.50	0.1254

TABLE 17
24" LINE - SINTER PLANT TO THICKENER
FLOW 288,000 GPD

	High	Low ppm	Average	Lbs/Ton
pH	8.8	8.5	8.7	
Alkalinity	40.0	34.0	37.0	0.023
Suspended Solids	1107.0	265.0	435.0	0.268
Total Iron	241.0	105.0	135.0	0.083

TABLE 18
COOLING WATER FROM NO. 2
BLAST FURNACE AT NO. 4 MANHOLE
FLOW 9,072,000 GPD

	High	Low ppm	Average	Lbs/Ton
pH	8.0	7.90	7.95	
Alkalinity	78.0	76.00	77.00	0.753
Suspended Solids	158.0	50.00	104.00	1.035
Dissolved Solids	287.0	205.00	246.00	2.404
Chlorides	44.5	23.50	39.00	0.300
Phosphates	3.4	0.98	2.20	0.021

Recommendations

A significant volume of water is used in washing the blast furnace flue gas free of dust particles. This water is discharged to two thickeners. The principal waste characteristic of this water is its high suspended solids content, averaging about 1,200 ppm. The thickener efficiency is better than average with the effluent containing approximately 50 ppm suspended solids. At present only 6,300 gpm of an available 20,000 gpm is recirculated from the thickeners to No. 2 blast furnace as cooling water.

The solids removal can be further improved through the use of polyelectrolytes.

Table 1 shows the results of using three different brand name polyelectrolytes. The wastewater responded best to a high molecular weight, anionic polyelectrolyte of low charge. No pH adjustments were made. Measurements of zeta potential were only made prior to each jar test. This was done to get an idea of how the colloids in each system were charged.

The value found correlates well with the way anionic polyelectrolytes react in negative colloid systems. For example, the blast furnace water had a zeta potential of -15 MV which suggests a low charge anionic material.

The blast furnace operation presents a potential for reducing water use and effluent volume significantly because of the large volumes of water involved and because reuse has been demonstrated successfully. The present operation is shown schematically in Figure 6.

The scheme presently used results in a total effluent volume from the operation of 38,000 gpm. Total water intake is 40,000 gpm and total water use is 51,000 gpm. The proposed system is shown in Figure 7.

The scheme of Figure 7 would entail a total water intake of 17,000 gpm and would result in an effluent volume for 9,980 gpm. The water intake would be cut in half and the effluent volume reduced by a factor of about 2.5. This represents the maximum practicable water reuse in the blast furnace department, short of the use of cooling towers.

Because of the high volume of the blast furnace waste streams, consideration was not given to cotreatment in this area.

TABLE 1

BLAST FURNACE THICKENER INFLUENT

POLYMER STUDIES

		Polymer					
		A		B1		B2	
Jar No.	Polymer Conc. (ppm)	Residual S.S. (mg)	% S.S. Removal	Residual S.S. (mg)	% S.S. Removal	Residual S.S. (mg)	% S.S. Removal
1	0	58.0	0	58.0	0	58.0	0
2	0.05	25.0	56.8	6.9	88.1	29.9	48.4
3	0.1	24.4	57.8	7.0	87.9	28.6	50.6
4	0.5	15.5	73.3	8.9	84.6	18.4	68.3
5	1.0	14.6	74.8	7.2	87.6	14.2	75.6
6	2.0	13.3	77.1	10.5	81.9	15.0	74.2
7	5.0	12.8	77.9	11.8	79.6	15.8	72.7

Raw Sample Analysis

TSS 345 mg/l
Alkalinity 116mg/l as $CaCO_3$
Hardness 217mg/l as $CaCO_3$
pH 7.4
Zeta Potential -15

A - Low charge high molecular weight acrylamide base polymer

B1 - Sulfonated polystyrene (non marketed) - high molecular weight

B2 - Sulfonated polystyrene - high molecular weight

TABLE 1 (Continued)

BLAST FURNACE THICKENER INFLUENT

Jar No.	Polymer Conc. (ppm)	Polymer B3 Residual S.S. (mg)	Polymer B3 % S.S. Removal	Polymer B4 Residual S.S. (mg)	Polymer B4 % S.S. Removal	Polymer C Residual S.S. (mg)	Polymer C % S.S. Removal
1	0	58.0	0	58.0	0	58.0	0
2	0.05	24.4	57.9	51.4	11.4	26.9	53.7
3	0.1	24.1	58.5	53.1	8.5	23.1	60.2
4	0.5	23.9	58.7	32.7	43.6	14.9	74.3
5	1.0	18.2	68.5	29.3	49.4	14.1	75.6
6	2.0	17.4	69.9	25.3	56.4	11.8	65.3
7	5.0	15.1	74.0	21.5	63.0	29.6	49.0

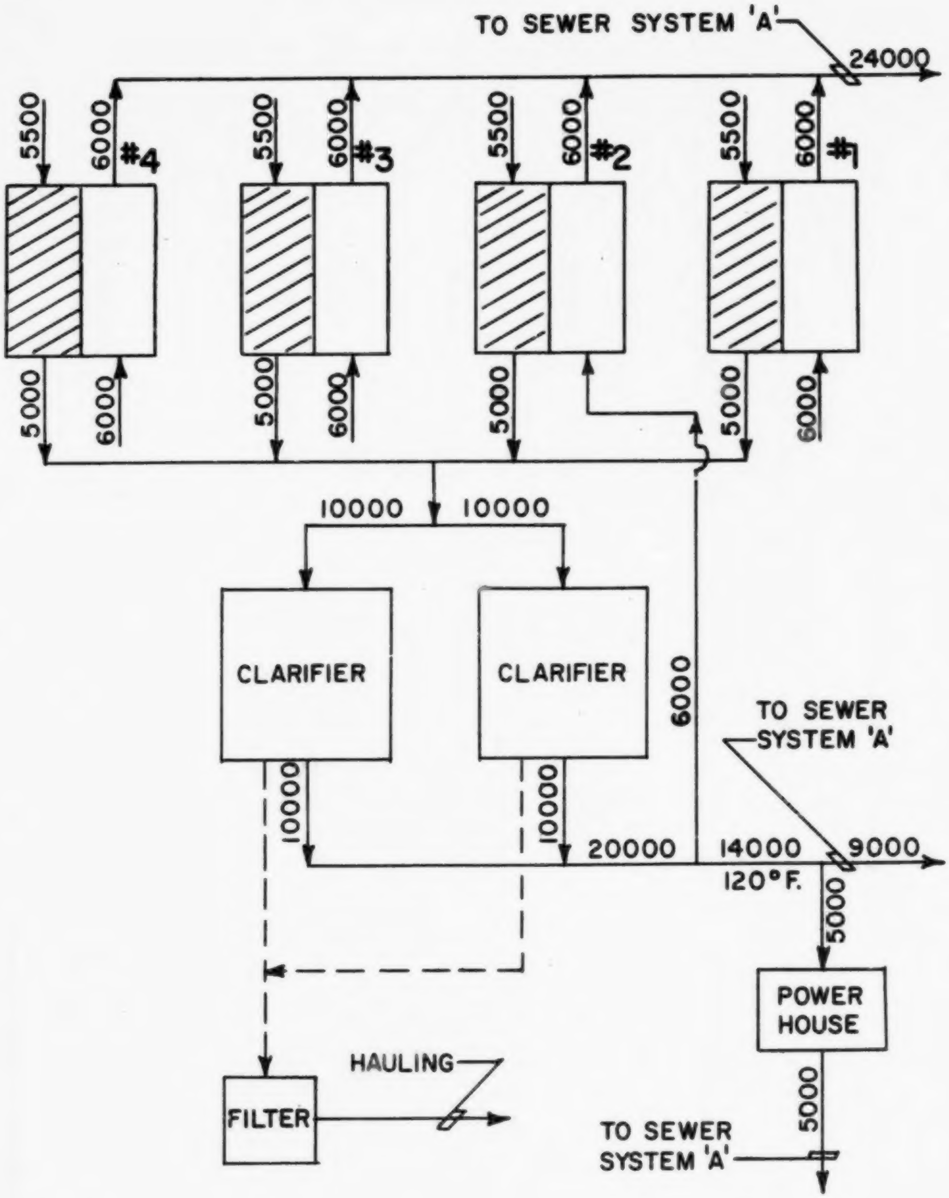
Raw Sample Analysis

TSS 345 mg/1
Alkalinity 116mg/1 as $CaCO_3$
Hardness 217 mg/1 as $CaCO_3$
pH 7.4
Zeta Potential -15

B3 - Sulfonated polystyrene - medium molecular weight

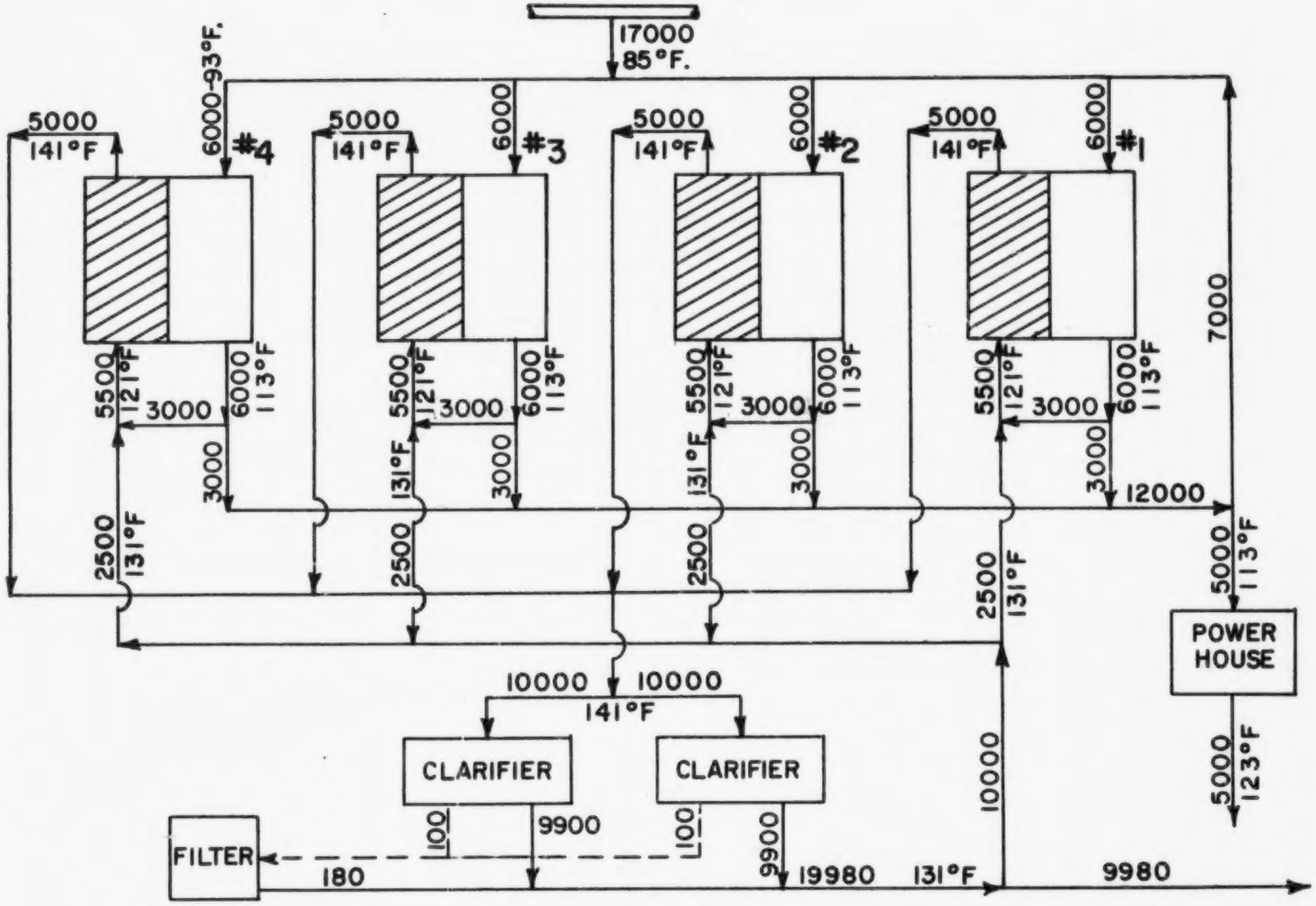
B4 - Sulfonated polystyrene - below medium molecular weight

C - Sulfonated polystyrene - medium molecular weight



PRESENT BLAST FURNACE WATER SYSTEM

FIGURE 6



PROPOSED BLAST FURNACE RECIRCULATION

FIGURE 7

Boiler House and Power House

A large block of power required to operate the steel facility is plant generated. Therefore, this requires a great volume of water which is used nonconsumptively for cooling in the condensers of the steam turbines at the power house. However, this use does not alter the chemical composition of the water. Generally raw water will serve for cooling purposes in power generation.

For certain industrial uses, water must pass a high degree of purity. Boiler water for steam generation must be of high purity to minimize scale deposits on heat transfer surfaces, and to control corrosion in boilers, condensers, and associated piping. The steam is used to drive turbines for electric power generation or to drive turboblowers, in both of which uses, a great deal of water must be circulated through the condensers serving the turbines.

In order to produce the water of controlled purity, boiler feedwater is treated in a three step process: hot softening, filtering, and deaeration. Raw river water enters the plant, is softened by the addition of lime and soda ash. It is here the calcium and magnesium are complexed and a slight suspension is formed. The water then proceeds through anthracite filters to remove suspended material. Next step is deaeration for removal of oxygen and the addition of sodium sulfite to drive remaining oxidizing gases. The water then proceeds to the boiler for internal chemical treatment, primarily a phosphate compound.

Another source of water at the boilers is for the ash removal system. Coal is delivered to the boiler house from the coal washing plant. The ash is wet down and then conveyed to a holding tank. Water enters a flume and is conveyed to the "A" sewer. Overflow water from the holding tank also enters the "A" sewer.

The following locations were sampled at the boiler house and power house area:

△19 Discharge from ash collector

△20 Filter backwash and ash conveyor water

△21 Power house drains

△22 Boiler water reactor tank

23 Ash pit influent

24 No. 8 manhole before boiler house

Analyses run on samples from the above locations include:

1. pH
2. Alkalinity
3. Suspended Solids
4. Dissolved Solids
5. Chlorides
6. Phosphates

The analytical data are given in Tables 19 through 24 .

TABLE 19
DISCHARGE FROM ASH COLLECTOR -
NO. 7 MANHOLE
FLOW 1,400,000 GPD

	High	Low ppm	Average
pH	8.1	7.0	7.60
Alkalinity	36.0	32.0	34.00
Suspended Solids	165.0	47.0	106.00
Dissolved Solids	314.0	304.0	309.00
Chlorides	29.5	26.0	27.70
Phosphates	1.9	1.2	1.55

TABLE 20
FILTER BACKWASH & ASH CONVEYOR WATER
NEAR NO. 6 MANHOLE
FLOW 72,000 GPD

	High	Low ppm	Average
pH	-	-	4.1
Alkalinity	-	-	8.0
Suspended Solids	-	-	61.0
Dissolved Solids	-	-	304.0
Chlorides	-	-	25.0
Phosphates	-	-	1.5

TABLE 21
POWER HOUSE DRAINS
FLOW 144,000 GPD

	High	Low ppm	Average
pH	6.8	6.7	6.75
Alkalinity	110.0	88.0	99.00
Suspended Solids	175.0	29.0	102.00
Dissolved Solids	410.0	223.0	316.50
Chlorides	44.6	33.5	39.00
Phosphates	3.4	3.3	3.35

TABLE 22
REACTOR TANK
FLOW 36,000 GPD

	High	Low ppm	Average
pH	10.8	9.1	10.0
Alkalinity	252.0	52.0	152.0
Suspended Solids	912.0	-	913.0
Dissolved Solids	429.0	300.0	364.5
Chlorides	29.0	24.0	26.5
Phosphates	8.9	8.6	8.8

TABLE 23
ASH PIT INFLUENT
FLOW 720,000 GPD

	High	Low ppm	Average
pH	9.6	8.2	8.9
Alkalinity	40.0	40.0	40.0
Suspended Solids	1425.0	140.0	783.0
Dissolved Solids	300.0	277.0	288.0
Chlorides	29.5	25.5	27.5
Phosphates	3.4	2.9	3.2

TABLE 24
NO. 8 MANHOLE -
BEFORE BOILER HOUSE
FLOW 14,400,000 GPD

	High	Low ppm	Average
pH	8.2	7.1	7.7
Alkalinity	40.0	34.0	37.0
Suspended Solids	140.0	48.0	94.0
Dissolved Solids	335.0	277.0	306.0
Chlorides	29.5	25.0	27.5
Phosphates	6.6	2.9	4.8

Recommendations

Wastewaters from this area were not considered for co-treatment. Consideration should be given to reuse schemes for the huge volumes of water that are now being discharged to the sewer.

Blooming Mill - Structural Mill

With continuous casting in its infancy, most steel plants still utilize both primary and secondary rolling mills. In general, the primary mill reduces the ingot to a slab or billet, and the secondary mill further reduces the slab or billet to a plate, shape, or strip.

The basic operation in a primary mill is the gradual compression of the steel ingot between the surfaces of two rotating rolls, and the passing of the ingot through the space between the rolls. Normally a number of passes in sequence are necessary to achieve the proper deformation of the steel. As the ingot enters the rolls, high pressure water sprays remove surface scale.

Descaling sprays are located on the top roll carrier on the delivery side of the mill. Descaling pumps with a capacity of 10,000 gpm operate at a pressure of 750 psi. Mill scale is washed into a scale pit and removed by grab bucket on an overhead crane.

Upon achieving the desired shape and shearing of the end, this semifinished produce is now ready for subsequent rolling operations, or in some instances may pass to an operation that removes surface defects.

At one time surface defects were removed by hand chipping, machine chipping, or grinding. Today one of several types of scarfing is generally used. Scarfing is a process of supplying streams of oxygen as jets to the surface of a steel product under treatment, while maintaining high surface temperatures that result in rapid oxidation and localized melting of a thin layer of metal. The process may be done manually but in recent years the oxygen lanced hot scarfing machine is used more frequently. The hot scarfer is generally located along side of the mill, and as the red hot bloom or billet moves down the line through the mill, a thin layer of metal is removed from all four sides.

The structural mill is the most common of several type mills in which special shapes can be rolled from blooms. These shapes would include I-beams, channels, angles, sheet piling, and rails to mention only a few.

Water Uses

The principal water uses in this operation are for cooling and flume flushing. During operation of a blooming mill, a liberal supply of cooling water should be distributed uniformly over the rolls. The water is generally off when the mill is not rolling. If water is kept flowing, the rolls are kept turning to avoid uneven cooling which is one of the most common sources of cracks in rolls.

High pressure spray water is used under the mill to convey the scale to settling pits. These pits are dredged continually and the water phase is discharged to the "A" system.

Only furnace cooling water from the structural mill flows to the "A" system. The major portion of the structural mill water flows to the "C" system. Therefore, discussion of this mill is included under that section.

At the hot scarfer water is used to convey the scale that has been removed by the oxygen jets to a scale pit. This pit is periodically cleaned and the water is discharged to the "A" system.

Four sampling locations were selected in the blooming mill area:

25 Blooming mill to main sewer

26 Scale pit at scarfing mill

27 Structural mill and blooming mill cropper

28 Beginning of main sewer

The following analyses were run on approximately 200 samples:

1. Temperature
2. pH
3. Suspended Solids
4. Oil

Analytical data is summarized in Tables 25 through 28 .

TABLE 25
BLOOMING MILL TO MAIN SEWER
FLOW 10,000,000 GPD

	High	Low ppm	Average	Lbs/Ton Rolled
Temperature	104°F	94°F	100°F	
pH	8.0	7.2	7.7	
Suspended Solids	137.0	19.0	76.0	0.857
Oil	7.7	6.2	7.0	0.079

TABLE 26
SCALE PIT AT SCARFING MILL
FLOW NOT AVAILABLE

	High	Low ppm	Average
Temperature	103°F	90°F	98°F
pH	7.4	7.2	7.3
Suspended Solids	-	-	73.0
Oil	-	-	24.3

TABLE 27
STRUCTURE MILL AND BLOOMING MILL CROPPER
FLOW NOT AVAILABLE

	High	Low ppm	Average
Temperature	-	-	140°F
pH	-	-	7.3
Suspended Solids	-	-	81.0
Oil	-	-	9.0

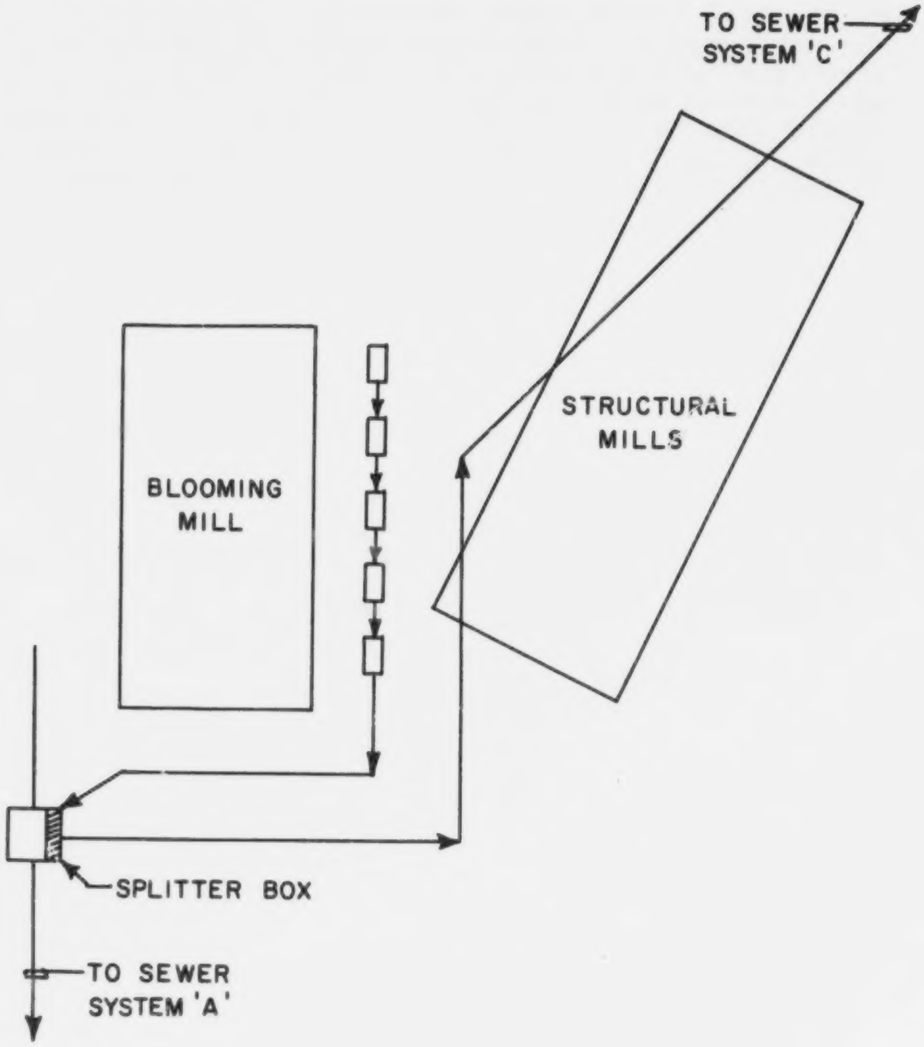
TABLE 28
BEGINNING OF EGG-SHAPED SEWER
FLOW 1,440,000 GPD

	High	Low ppm	Average	Lbs/Ton Rolled
Temperature	104°F	99°F	101°F	
pH	7.5	7.2	7.3	
Suspended Solids	190.0	12.0	84.0	0.1350
Oil	4.7	3.7	4.2	0.0067

Recommendations

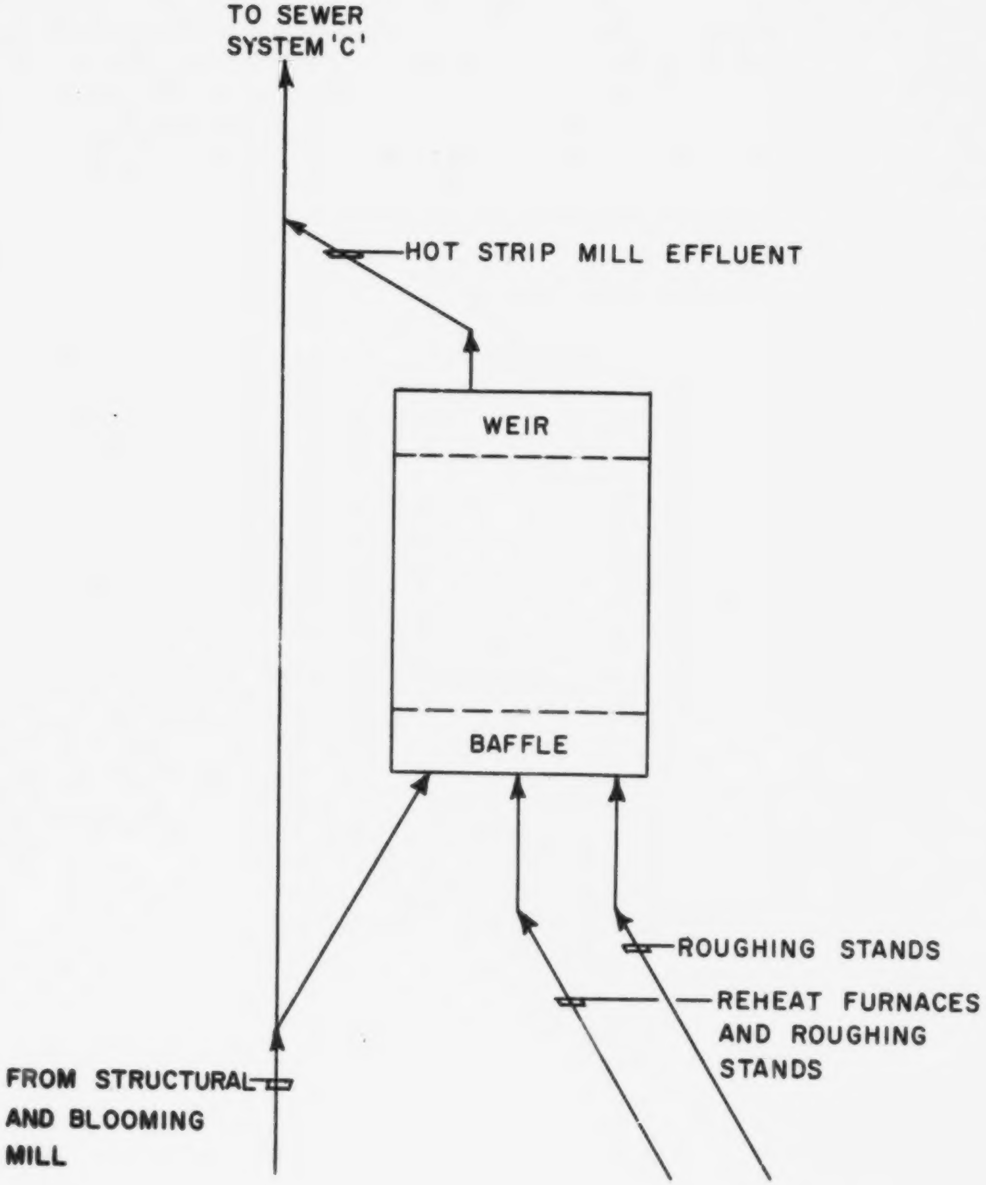
Wastewater treatment in the blooming and structural mill area is minimal. There are several small pits that are removing primarily large pieces of solid materials but are generally inadequate for scale removal. There is a definite need for better designed scale pits and installation of oil removal equipment to improve the quality of wastewater discharged from these areas. Another alternative is the use of the splitter box discussed below which would reduce the discharge volume and provide water for reuse.

Presently wastewater from the structural mills flows through the "C_2" system and wastewater from the blooming mill flows through "A" system as shown in Figure 8. Since the principal pollutant in both of these processes is suspended solids, they may be treated within a similar system. A splitter box located alongside the blooming mill would divert scale-bearing water from the blooming mill into the "C_2" system and shortly thereafter would pickup wastewater from the structural mills.



BLOOMING-STRUCTURAL MILL
WASTE FLOW
FIGURE 8

As the "C_2" system flows alongside of the scale pit for the hot strip mill, a significant amount of wastewater from the structural and blooming mill can be diverted through the scale pit as shown in Figure 9. An oil collection skimmer should also be installed at this scale pit. The remaining water can be discharged to the lagoon at "C" system which includes provisions for settling and oil skimming facilities.


TO SEWER SYSTEM 'C'
HOT STRIP MILL EFFLUENT
WEIR
BAFFLE
ROUGHING STANDS
REHEAT FURNACES AND ROUGHING STANDS
FROM STRUCTURAL AND BLOOMING MILL

BLOOMING-STRUCTURAL MILL
WASTE TREATMENT
FIGURE 9

Section V

Sewer System B

Wastewaters that discharge to sewer system B originate from the following areas:

Continuous anneal lines
Weirlite mills
Electroplating lines
Demineralization plant

A schematic of sewer system B is shown in Figure 3. Sampling points and flow rates for the various wastewater streams are indicated on the schematic. Approximately 1200 samples taken at eight sampling points were analyzed for the following:

1. pH
2. Alkalinity
3. Acidity
4. Sulfates
5. Suspended Solids
6. Total iron
7. Tin
8. Total chrome
9. Hexavalent chrome
10. Fluorides
11. Oil
12. Chlorides
13. Cyanide
14. Temperature

Continuous Anneal Lines

The purpose of the continuous anneal lines is to clean and properly recrystallize the steel structure, ready to be temper rolled or reduced on the Weirlite mill immediately after annealing. These lines replace the functions of separate cleaning lines and batch anneal furnaces and provide a more uniform product. The lines contain an entry section, an annealing section, and a delivery section. All the components in the delivery section are primarily mechanical and include no wastewater functions. In addition to the mechanical operations, the entry section contains a cleaning tank, and the annealing section contains a water quench and a fast cool zone.

The solution used in the cleaning section is a nonsilicated cleaning compound containing additional wetting agents.

The fast cool section contains water jackets through which water is passed to cool the atmosphere in this section.

The function of the quench tank is to provide a reduction in the strip temperature.

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There are presently two continuous anneal lines in operation and a third is under construction.

Wastewaters emanating from the continuous anneal lines consist of solution overflow from the cleaning tank made up of high alkaline substances also containing significant amounts of phosphorus and silicon. Substantial amounts of oil are also removed in the cleaning and scrubbing sections.

Analytical data are given in Tables 29 and 30 .

TABLE 29
NO. 1 CONTINUOUS ANNEAL LINE SCRUBBER

	High	Low	Average
		ppm	
pH	12.0	10.4	11.4
Pht. Alkalinity	800.0	70.0	417.6
M.O. Alkalinity	1270.0	200.0	649.0
Suspended Solids	1087.00	128.00	490.4
Total Iron	196.00	90.50	114.2
Oil	805.30	55.10	254.1
Phosphorus	54.40	8.80	29.9
Silicon	8.88	2.34	5.2

TABLE 30
NO. 2 CONTINUOUS ANNEAL LINES SCRUBBER

	High	Low	Average
		ppm	
pH	12.0	9.2	10.6
Pht. Alkalinity	900.0	184.0	542.0
M.O. Alkalinity	210.0	90.0	150.0
Suspended Solids	370.0	341.0	355.5
Oil	169.5	100.7	134.1
Phosphorus	21.9	19.2	20.5
Silicon	7.4	1.9	4.7

Weirlite Mills

Following the cleaning, annealing and tempering, the strip passes to the Weirlite reduction mill which further reduces the coil thickness approximately 35% for the electroplating. This mill must also produce a good surface and shape. Rolling oil concentration from 5 to 10% is applied to the strip by jet sprays and water is applied by sprays to cool and strip where necessary.

Wastewaters from the Weirlite mill consist of emulsified oils, surface oils, scale and dirt. The mill consists of two lines generating significantly different volumes of wastewater. On one line the rolling solution is constantly being reused, generating wastewater as the solution becomes ineffective. The other line operates without the benefit of a reuse program and generates wastewater on a continuous basis. The discharges are being treated in a process which consists of chemical treatment, air flotation, oil separation and skimming.

Analytical data are given in Table 31. The variable product mix throughout the tin mill operation prohibits the use of production figures. Therefore, waste loads in pounds per ton are not included in the "B" sewer system.

TABLE 31
WEIRLITE MILLS - TREATMENT EFFLUENT
FLOW 288,000 GPD

	High	Low ppm	Average
pH	6.5	6.0	6.2
M.O. Alkalinity	26.0	24.0	25.0
Chlorides	27.0	25.0	26.0
Sulfates	120.0	46.0	108.0
Suspended Solids	57.0	18.0	37.5
Total Iron	1.0	0.8	0.9
Total Chrome		Not Detectable	
Tin		Not Detectable	
Oil	4050.0	265.9	1636.5

Recommendations

Wastes from the Weirlite mills are treated by chemical additions, air flotation, oil separation, and skimming. During the field work several abnormal oil concentrations were obtained in the effluent. These discharges were subjected to the treatability studies and were found to be an excellent source of food for the plant lab studies. Therefore, the Weirlite mill effluent could be put into the combined treatment plant.

Electro Plating Lines

After the strip has been temper rolled or double reduced it then passes to one of the electrolytic lines. The electrolytic process utilizes tin anodes and the steel strip is the cathode. The processes vary in their use of the electrolyte and include stannous sulfate - phenolsulphuric acid, alkaline stannate, and acid-halogen solutions. In the acid lines, the process sections consist of electrolytic alkaline cleaning, rinsing, pickling, plating, quenching, chemical treating, rinsing, drying and oiling. In the alkaline lines the alkaline cleaner is omitted since the alkaline plating bath itself does sufficient cleaning. Each of these operations requires considerable amounts of high quality water.

The electrolytic plating operations result in an effluent containing various metals including tin, chromium and zinc in addition to cyanides, alkali, and acids. The effluent is mainly in the form of rinses, sprays, and overflows from the plating process. Concentrated wastes including the heavy metal wastes and acid solutions are presently disposed of by contract hauling and treated outside the plant.

Analytical data are shown in Tables 32 through 34 .

TABLE 32
COMMON DISCHARGE NO. 1 AND NO. 2 ELECTROPLATING LINES
FLOW 3,916,800 GPD

	High	Low	Average
		ppm	
pH	7.1	6.2	6.70
M.O. Alkalinity	37.5	20.0	28.70
Chlorides	170.0	52.0	111.00
Sulfates	194.0	67.2	130.50
Suspended Solids	778.0	127.0	457.50
Total Iron	59.0	1.7	30.60
Total Chrome	91.5	6.5	49.00
Hexavalent Chrome	10.7	0.2	5.50
Cyanide	0.33	0.0	0.15

TABLE 33
NO. 4 TIN LINE MAIN SEWER
FLOW NOT AVAILABLE

	High	Low	Average
		ppm	
pH	7.4	3.50	6.40
Mineral Acidity	38.0	10.00	24.00
M.O. Alkalinity	42.0	4.00	23.50
Chlorides	97.0	28.00	39.10
Sulfates	206.8	78.00	104.60
Suspended Solids	145.0	27.00	80.20
Total Iron	9.20	0.13	4.40
Total Chrome	31.9	0.53	20.20
Hexavalent Chrome	29.0	0.50	10.40
Tin	108.2	4.80	48.90
Cyanide	1.0	0.32	0.74
Fluorides	61.0	12.00	27.00

TABLE 34
NO. 5 TIN LINE MAIN SEWER
FLOW NOT AVAILABLE

	High	Low	Average
		ppm	
pH	6.30	3.70	4.60
Mineral Acidity	154.00	6.00	63.10
M.O. Alkalinity	-	-	10.00
Chlorides	450.00	20.00	207.00
Sulfates	239.20	96.00	152.00
Suspended Solids	229.00	62.00	129.10
Total Iron	37.70	2.90	21.60
Total Chrome	26.40	10.10	15.50
Hexavalent Chrome	0.73	0.15	0.34
Tin	196.00	7.30	122.90
Cyanide	2.28	0.25	1.06
Fluoride	63.00	1.90	30.48

TABLE 35
NO. 6 TIN LINE MAIN SEWER
FLOW 3,773,000 GPD

	High	Low	Average
		ppm	
pH	4.9	2.8	3.9
M.O. Alkalinity	10.0	2.0	4.0
Chlorides	65.0	20.0	45.5
Sulfates	390.0	84.0	250.7
Suspended Solids	308.0	31.0	146.0
Total Iron	55.1	14.4	29.0
Total Chrome	3.8	0.8	2.1
Hexavalent Chrome	0.0	0.0	0.0
Tin	14.7	3.1	12.4
Cyanide	3.6	0.4	1.04
Fluorides	26.0	1.1	8.6

Recommendations

The greater portion of the wastes are dilute rinses and their volume is too great to be discharged into the sanitary sewer system. Therefore, any considerations given toward waste treatment must begin with separation of the concentrated wastes from those produced by quenching and rinsing.

Wastes from the plating lines were introduced into the treatability studies and found to be compatible and amenable to biological treatment. Therefore, it is recommended that pretreatment be performed at the steel plant on concentrated chromium wastes and this discharge be sent to the sanitary sewage plant. Pretreatment would consist essentially of reduction of hexavalent chrome to the trivalent form. A survey of concentrated dumps place a conservative figure of 200,000 gallons per year to be treated. Use should be made of concentrated wastes to fulfill pretreatment chemical requirements. Those available include:

1. Pickling solution (sulfuric acid)
2. Cleaning solutions (alkaline)
3. Demineralization waste (sulfuric acid)
4. Demineralization waste (sodium hydroxide)

Treatment of dilute wastes would entail an in-depth study to ascertain areas for water conservation and reuse schemes to reduce the volumes of wastes to be treated. In addition, consideration should be given to a centralized treatment system for the tin mill plating lines in conjunction with the nearby galvanizing lines. Once again, use should be made of the concentrated wastes as treatment chemicals in order to reduce the cost of treatment.

Demineralization Plant

The Tin Mill has its own water demineralization plant. This facility consists of an ion exchange operation that provides water for use in the final rinse tank on the electroplating lines.

Wastes from the demineralization plant consist of basically acid and alkaline regenerants. The volume of regenerants is a function of the volume of demineralized water processed.

Analytical data for the demineralizer plant effluent are shown in Table 36.

TABLE 36
DEMINERALIZER PLANT FINAL DISCHARGE
FLOW 144,000 GPD

	High	Low ppm	Average	Lbs/Gal. DM Water
pH	11.9	1.2	3.93	
Pht. Alkalinity	800.0	256.0	528.00	.001
M.O. Alkalinity	1100.0	728.0	914.00	.002
Mineral Acidity	7400.0	34.0	1521.00	.0037
Total Dissolved Solids	5675.0	238.0	1340.00	.0033

Recommendations

Efforts should be made for efficient and conservative use of demineralized water.

Section VI

Sewer System C

Wastewaters that discharge to sewer system C originate from the following areas:

Tandem Mills
Palm Oil Recovery
Hot Strip Mill
Pickling Lines
Galvanizing Dept. (Sheet Mill)
Diesel and Car Shop
Structural Mill

A schematic of sewer system C is shown in Figure 4. Sampling points and flow rates for the various wastewater streams are also indicated on the schematic. Approximately 1500 samples taken at various discharge points were analyzed for the following:

1. pH
2. Alkalinity
3. Suspended Solids
4. Total Iron
5. Oil
6. Total Chrome
7. Hexavalent Chrome
8. Phosphates
9. Silicon
10. Acidity
11. Chlorides
12. Total Dissolved Solids
13. Ferrous Iron
14. Sulfates
15. Temperature

Tandem Mill

The primary function of the tandem mill is cold reducing. Cold reduction is a special form of cold rolling in which the thickness of the starting material can be reduced in a series of passes through a tandem cold mill. The use of rolling oil is necessary in the process to minimize friction between the strip and the rolls. The department has four tandem cold mills; two five stand and two four stand. Two of the units utilize recirculating solution rolling systems. The other two are once-through systems. Two of the mills discharge on a continuous basis and the mills on recirculation dump on a batch basis. Principal wastes include oils and suspended solids. Average reductions at high speeds generate a heat load on the product as well as the rolls. This heat gradient is controlled by a system of flood lubrication in which palm oil or water soluble oils are directed in small streams or jets against the roll bodies and the steel surface. In other instances palm oil may be used on the steel and high pressure water on the rolls. The combined cold roll and reduction mills reduce the product thickness and then provide a smooth, lustrous finish. There are three (3) types of wastes discharged from the tandem mills:

1. Raw water and oil applied on the mill at the Nos. 5 and 8 Tandem Mills which goes to palm oil recovery plant. This is a once-through system.

2. Nos. 6 and 7 Tandem Mills solutions are on a recirculating system. After being used the solution drains to the oil cellar, is filtered, undergoes temperature control and is pumped back to the mill. When contaminated, it too is pumped to the palm oil recovery plant. This combined total amounts to about 1,000,000 gpd.

3. Cooling water on the Morgoil Lube System heat exchangers and the heat exchangers from the solution systems on Nos. 6 and 7 Tandems which goes directly to the river.

The oil waste streams (Nos. 1 and 2) from the Tandem Mills are treated at the palm oil recovery plant. The heat exchanger cooling water (No. 3) is used for indirect cooling and does not change appreciably as it passes through the system. For these reasons, samples were not taken at these locations.

Palm Oil Recovery, Inc.

Wastes from the tandem mill flow to the palm oil recovery plant. Here the wastes are subjected to treatment including chemical additions, air flotation, sedimentation, and skimming.

The palm oil recovery plant treats over 1,000,000 gpd of waste oils. Most of this oil is pumped from the tandem mills. Treatment consists primarily of settling, chemical additions, application of heat, air flotation, additional settling, and finally skimming. After treatment the oil is returned to large storage tanks at the pickler building. The oil is then applied to the hot mill bands after pickling. The underflow is discharged to the river and amounts to about 1,000,000 gpd.

Analytical data are given in Table 37.

TABLE 37
PALM OIL RECOVERY PLANT EFFLUENT
FLOW 1,000,000 GPD

	High	Low ppm	Average	#/Ton Steel Cold Reduced
pH	7.2	2.2	4.6	
Total Acidity	835.0	2.0	183.8	0.229
Mineral Acidity	-	-	700.0	0.874
Total Iron	181.0	34.0	111.3	0.014
Oils	1534.0	80.0	376.0	0.470

Recommendations

The effluent from the primary portion of the treatment process exhibited excellent potential for biological food in the combined treatment plant. It is recommended that this effluent be discharged directly to the sanitary sewer system and combined with the municipal wastes in conjunction with the proposed co-treatment system.

Hot Strip

The function of the hot strip mill is to reduce a slab of steel to a relatively light sheet of semifinished steel. The first step is to determine the proper grade of steel and the size and surface quality of the slab necessary to make the order. Next is the operation of heating the slabs to rolling temperature. The slabs must be heated uniformly throughout and also must have a uniform scale coating that will clean readily in rolling. The third step is to rough down the slab to a predetermined thickness. The first rolling pass on the slab is done on a scale breaker which is followed immediately with a high pressure hydraulic spray to facilitate removal of the furnace scale. In addition, there are usually one or two more descaling sprays following the second and third roughing stands to remove further scale that may be loosened during rolling. Next, the finishing stand must be carefully regulated to obtain a finished hot rolled product of prime quality. A considerable amount of water must be used here in descaling sprays as spray patterns and time on the holding table all affect the finishing temperature. The final step in hot rolling is the deposition of the product. The greater portion of the product is handled by the hot coiling method.

Water is used quite extensively in the rolling mills on reheating furnaces to cool furnace doors and skid pipes. Water from high pressure jets is used to remove scale from the hot steel before rolling and to keep the surface clean between certain passes. The hot strip mill also uses cooling sprays over the runout table to cool the strip to the proper temperature for coiling.

The scale removed from hot steel by the high pressure jets falls into a flume or sluice beneath the mill, where a running stream of water carries the scale to a scale pit.

Seven (7) locations were sampled and should provide a good representation of discharges from the mill. Samples were taken at the following locations:

△38 Reheat furnace and first two roughing stands - 9,700,000 GPD.

△39 Last three roughing stands - 18,800,000 GPD

△40 Total effluent - Finish stands - 8,700,000 GPD

△41 Scale pit effluent - 28,500,000 GPD

Analytical data are shown in Tables △38 to △41.

TABLE △38
HOT STRIP REHEAT FURNACE
AND FIRST TWO ROUGHING STANDS
FLOW 10,000,000 GPD

	High	Low ppm	Average	Lbs/Ton
pH	7.2	6.7	7.0	
Suspended Solids	355.5	101.5	228.5	1.3760
Oil	15.1	13.0	14.0	0.0843
Chlorides	17.0	14.5	15.8	0.0951
Total Iron	-	-	120.6	0.7263

TABLE 39
HOT STRIP ROUGHING STANDS
FLOW 18,000,000 GPD

	High	Low ppm	Average	Lbs/Ton
pH	6.7	6.5	6.6	
Suspended Solids	430.8	123.0	276.5	5.4000
Oil	19.4	8.6	14.0	0.2754
Chlorides	17.5	15.5	16.5	0.3246
Total Iron	-	-	150.8	2.9000

TABLE 40
HOT STRIP FINISH STANDS - TOTAL EFFLUENT
FLOW 13,000,000 GPD

	High	Low ppm	Average	Lbs/Ton
pH	7.1	6.6	6.9	
Suspended Solids	256.0	112.5	201.0	1.8160
Oil	90.6	12.9	35.6	0.3216
Chlorides	18.5	17.0	17.8	0.1608

TABLE 41
HOT STRIP SCALE PIT EFFLUENT
FLOW 28,000,000 GPD

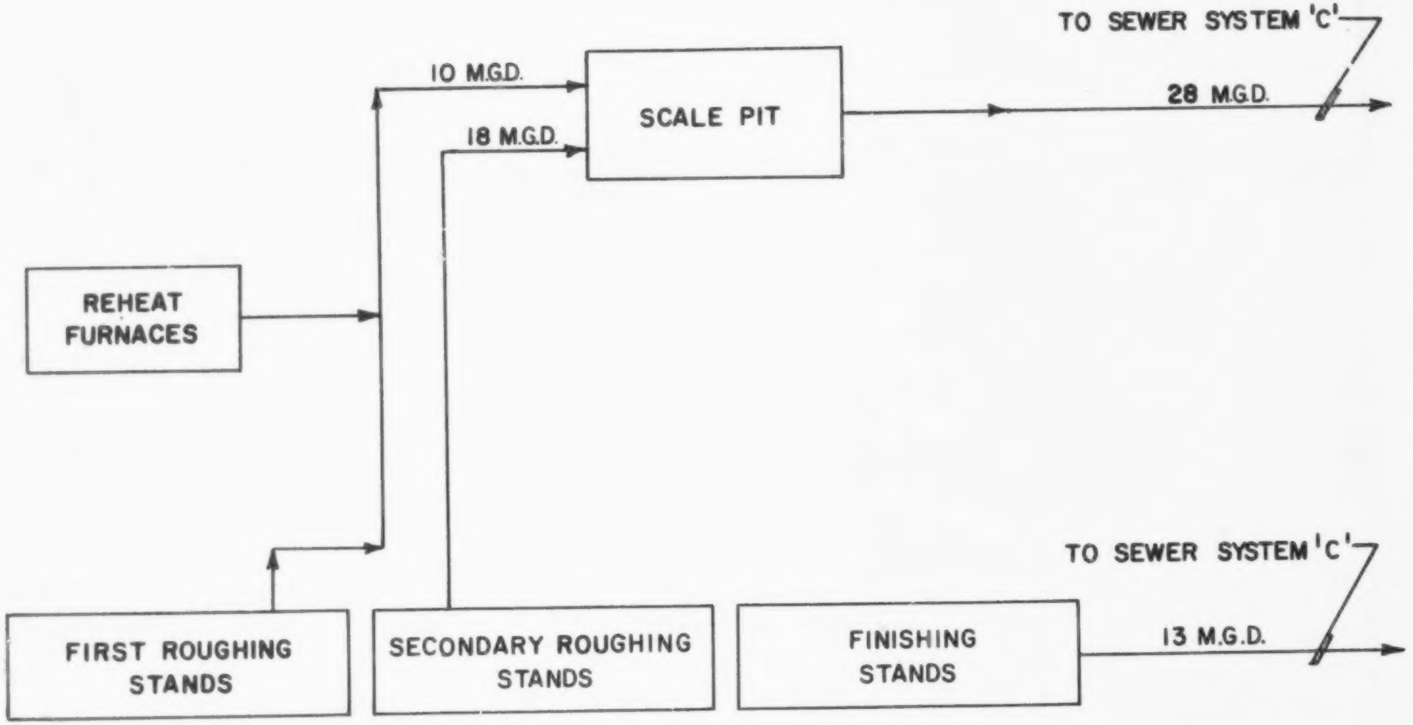
	High	Low ppm	Average	Lbs/Ton
pH	6.8	6.6	6.7	
Suspended Solids	126.5	47.0	86.8	2.6000
Oil	14.3	5.5	8.9	0.2646
Chlorides	17.0	16.0	16.5	0.4906
Total Iron	-	-	175.9	5.2000

Recommendations

Under the present operation the wastewater from the finish stands is discharged directly to the "C" sewer system. This could be diverted for flume flushing on the roughing stands sluice way and then discharged to the scale pit. The scale pit should also be equipped with a more efficient system for oil and solids removal. As an intermediate step the scale pit performance should be evaluated with polyelectrolytes to determine the improved efficiency with the use of various flocculating aids. The present performance of the scale pit is less than adequate, but on several occasions after dredging the pit, the suspended solids discharge was less than 50 ppm. This indicates that more frequent pit cleaning would improve overall scale pit performance.

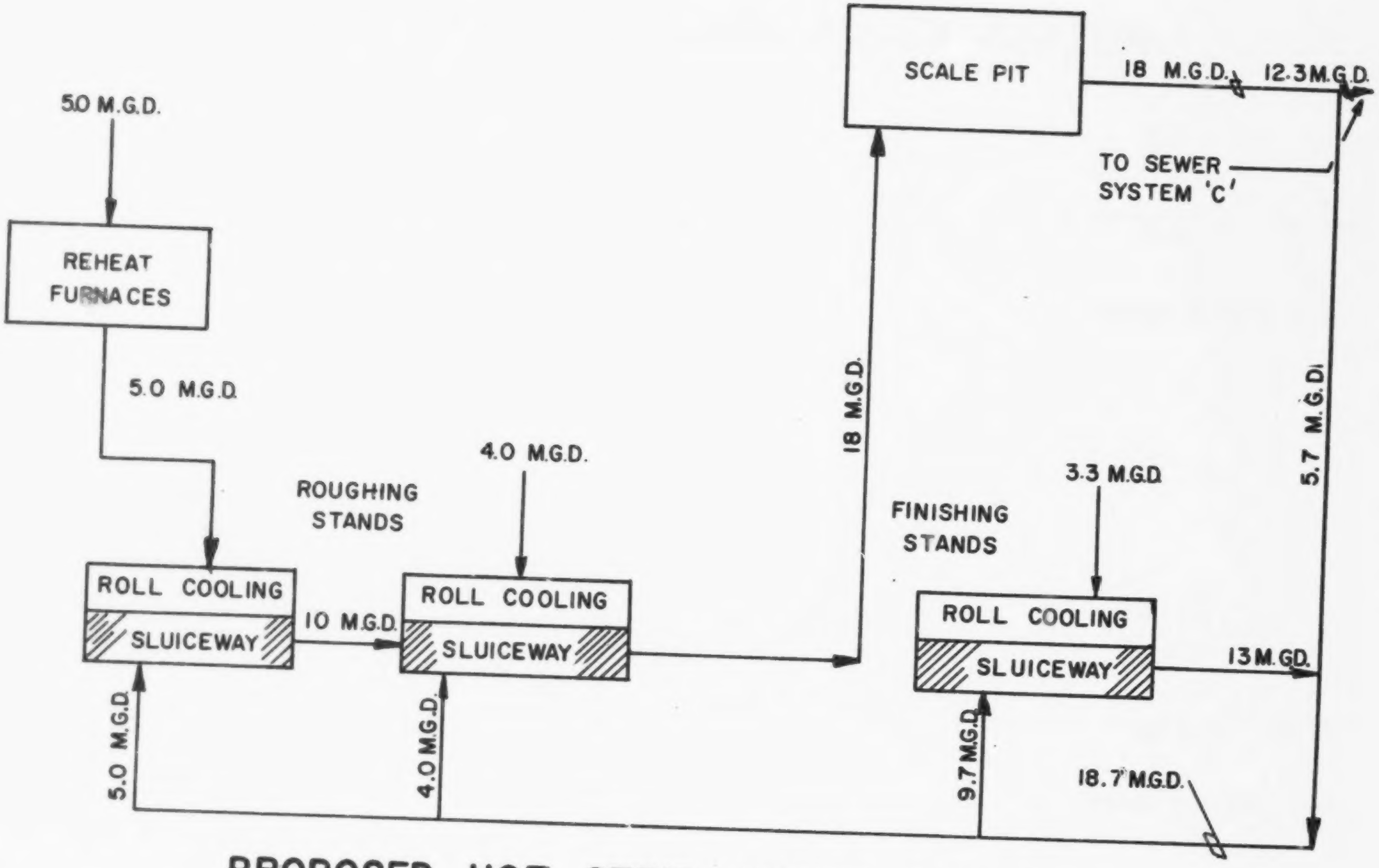
The hot strip, similar to the blast furnace, presents the potential for water reuse and reduction of total discharge volume. The present system is shown in Figure 10.

The proposed scheme is shown in Figure 11 in which it is assumed that the 10 MGD stream to the scale pit is 50% furnace cooling water, and that 75% of the water requirement on the mills is for flume flushing. With the complete proposed management, the total effluent would be reduced by more than 50% and the total effluent solids would be reduced by reduction of the flow through the scale pit and the retention of the finishing stand wastewater. In addition, the problems associated with heat build up should be investigated, and the potential for a cooling tower installation should be evaluated.



PRESENT HOT STRIP WATER SYSTEM

FIGURE 10



PROPOSED HOT STRIP WATER SYSTEM

FIGURE 11

Pickling Lines

The function of the pickling lines is the removal of the scale formed in the rolling process. In the production of the cold reduced steel, it is necessary that all scale be removed to prevent lack of uniformity and eliminate surface irregularities.

This mill has four continuous picklers utilizing hydrochloric acid. Untreated but strained river water is used in the entire operation.

In addition to the usual handling equipment, the pickling line consists of several individual acid-proof tanks located in a series. Following the acid tanks are rinsing tanks. The cold water rinses the acid carryover from the steel. The hot water rinse warms the steel and produces flash drying prior to recoiling. Concentration of the acid bath will vary with the type and grade of steel being processed.

Wastewaters from the continuous picklers originate as tank overflow, rinse sprays, scrubber flow, and looping pit discharges. Several safety hazards prohibited a detailed survey of all the pickling facilities, and hence the bulk of the field work was conducted at the No. 4 pickler. Each of the three picklers discharge approximately 800,000 GPD of dilute wastes and the fourth discharges approximately 1,000,000 GPD.

Analytical data are shown in Tables 42 through 43.

TABLE 42
NO. 4 PICKLE LINE
SCRUBBER DISCHARGE
FLOW 235,000 GPD

	High	Low ppm	Average	#/Ton Steel Pickled
pH	3.1	1.6	2.2	
Mineral Acidity	2060.0	80.0	945.0	1.26
Total Acidity	5720.0	140.0	2220.0	2.96
Chlorides	4350.0	200.0	1600.0	2.13
Total Iron	3266.0	32.6	760.0	1.01

TABLE 43
NO. 4 PICKLER
TANK OVERFLOW
FLOW 22,000 GPD

	High	Low	Average	#/Ton Steel Pickled
		ppm		
Mineral Acidity	12759	7192	8778	1.07
Chlorides	218000	170000	193666	23.63
Total Solids	406554	283580	349835	42.68
Suspended Solids	598	65	315	0.038
Total Iron	155775	110510	137154	16.73

Together four (4) continuous strip picklers contribute up to 100,000 gallons of waste hydrochloric acid pickle liquor per day. Presently the waste pickle liquor is disposed of by contract hauling to a waste site outside the city where it is neutralized with lime and settled out in a lagoon. Periodically the lagoons are dredged and the settled precipitate is used as fill. The plant presently has under study several methods other than hauling and off-site neutralization for disposal of waste HCl pickling solutions. These include:

1. Deep well disposal
2. On-site neutralization
3. Hydrochloric acid recovery methods

Scrubber rinse waters from the No. 4 pickler were utilized in the laboratory studies for pH control. However, the volume that can be taken to the plant will vary with the pH of the wastes utilized in the demonstration plant.

Galvanizing Department (Sheet Mill)

The Galvanizing Department consists of four (4) galvanizing lines, a cleaning line, box annealing facilities, a flying shear cutting line, and batch pickling facilities. Potential waste sources include pickle rinses, orthosilicate tank overflows, scrubber waters, and rinse tank discharges.

Pickling for sheet galvanizing is conducted as a batch operation. Very light pickling requiring only a short time exposure to the pickling solution is generally suitable for products such as roofing and siding. Deep etching is necessary when forming requirements are severe.

The four (4) lines employ basically the same process. The material arrives at the lines from the Cold Reduction Mills. The material is normally not cleaned, annealed, or skin rolled prior to line processing. Entry and equipment consists of uncoilers, shears, and a welder. The material is cleaned in the line, annealed, coated, and cooled.

In the cleaning line the strip is passed through an aqueous solution of orthosilicate and alternating grids to facilitate electrolytic cleaning. The line is further composed of such conventional equipment as a pay off reel, welder, scrubber, wringer rolls, hot air drying, loop pit, tension unit, and winding reel.

The annealing equipment is of a conventional style of three or four stack box annealing. The anneal cycle varies according to the material being annealed and the physical properties desired.

Wastewaters from the galvanizing operation consist primarily of orthosil tank carryover, scrubber waters, and rinses. Total discharge from the department to the "C" system approximates 4,000,000 GPD. In addition to sampling at the main discharge sump, samples were also taken at various discharge points on the cleaning and galvanizing lines as indicated:

No. 1 Cleaning Line

44 Final rinse - Flow 22,000 GPD

45 Scrubber discharge - Flow 15,000 GPD

46 Orthosil tank overflow - Flow 1,500 GPD

Galvanizing Lines

47 Scrubber - Flow 15,000 GPD

48 Scrubber - Flow 22,000 GPD

49 Orthosil Tank - Flow 1,500 GPD

50 Total Galvanizing Plant Discharge

Analytical data are given in Tables 44 through 50.

TABLE 44
NO. 1 CLEANING LINE
FINAL RINSE TANK OVERFLOW
FLOW 22,000 GPD

	High	Low ppm	Average	Lbs/Ton Cleaned
pH	11.7	10.8	11.2	
Pht. Alkalinity	750.0	60.0	334.0	0.202
M.O. Alkalinity	836.0	140.0	347.0	0.203
Suspended Solids	5642.0	79.5	2960.0	1.780
Oil	400.0	6.6	129.5	0.078
Phosphorus	12.0	2.9	7.6	0.005
Silicon	590.0	6.1	205.8	0.124

TABLE 45
NO. 1 CLEANING LINE
SCRUBBER OVERFLOW
FLOW 15,000 GPD

	High	Low ppm	Average	lbs/Ton Cleaned
pH	11.6	11.1	11.3	
Pht. Alkalinity	380.0	26.4	221.6	0.091
M.O. Alkalinity	487.0	288.0	380.0	0.157
Suspended Solids	604.0	132.0	311.0	0.129
Oil	53.8	40.3	47.0	0.019
Phosphorus	8.9	4.8	6.6	0.003
Silicon	-	-	83.6	0.034

TABLE 46
NO. 1 CLEANING LINE
ORTHOSIL TANK OVERFLOW
FLOW 1,500 GPD

	Average ppm	Lbs/Ton Cleaned
pH	13.0	
Pht. Alkalinity	136.0	0.006
M.O. Alkalinity	496.0	0.020
Suspended Solids	1571.0	0.064
Oil	701.0	0.029
Phosphorus	4.8	0.001
Silicon	2080.0	0.086

TABLE 47
NO. 2 GALVANIZING LINE SCRUBBER OVERFLOW
FLOW 15,000 GPD

	High	Low ppm	Average	Lbs/Ton Galvanized
pH	12.1	11.65	11.9	
Pht. Alkalinity	1100.0	440.00	867.0	0.067
M.O. Alkalinity	1180.0	535.00	942.0	0.073
Suspended Solids	434.0	301.00	359.0	0.028
Oil	157.0	100.00	123.0	0.001
Phosphorus	4.6	2.40	3.8	0.0003
Silicon	202.4	70.10	153.4	0.012

TABLE 48
NO. 3 GALVANIZING LINE SCRUBBER OVERFLOW
FLOW 15,000 GPD

	High	Low	Average	Lbs/Ton Galvanized
pH	9.8	9.0	9.4	
Pht. Alkalinity	56.0	10.0	33.0	0.003
M.O. Alkalinity	76.0	46.0	61.0	0.006
Suspended Solids	36.0	26.5	31.2	0.003
Oil	-	-	14.2	0.0011
Phosphorus	8.0	0.8	4.4	0.0003
Silicon	-	-	5.9	0.00046

TABLE 49
NO. 3 GALVANIZING LINE
ORTHOSIL TANK OVERFLOW
FLOW 1,500 GPD

	High	Low ppm	Average	Lbs/Ton Galvanized
pH	13.0	11.8	12.4	
Pht. Alkalinity	9200.0	6800.0	8000.0	0.063
M.O. Alkalinity	10300.0	7600.0	8950.0	0.070
Suspended Solids	523.0	395.0	441.3	0.00034
Oil	23.2	12.0	17.6	0.00013
Phosphorus	-	-	591.7	0.0046
Silicon	-	-	1182.0	0.0090

TABLE 50
TOTAL GALVANIZING DEPARTMENT DISCHARGE
FLOW 4,[illegible]0,000 GPD

	High	Low ppm	Average	Lbs/Ton Galvanized
pH	10.2	2.90	8.9	
Pht. Alkalinity	62.0	10.00	27.6	0.62
M.O. Alkalinity	104.0	42.00	65.8	1.48
Mineral Acidity	-	-	118.0	2.65
Total Iron	25.5	4.80	17.1	0.38
Chlorides	48.0	20.00	32.5	0.73
Suspended Solids	218.0	99.00	198.5	4.47
Phosphate	6.4	1.20	4.3	0.097
Silicon	20.9	13.80	17.9	0.38
Zinc	1.1	0.31	0.6	0.014
Total Chrome	3.3	0.56	1.5	0.030
Hexavalent Chrome	2.9	0.42	1.0	0.023

Recommendations

The greater volume of wastewaters from the department are rinse and cooling waters. However, there are overflows from the scrubber, final rinse, and orthosil tanks that contain significant amounts of oil, phosphorus, and suspended solids. These wastes were introduced into the laboratory studies and found amenable to treatment. Therefore, these wastes should be included for co-treatment in the combined treatment plant. Total volume of these wastes is about 25,000 GPD per line or 125,000 GPD from the five lines.

Diesel And Car Shops

The Diesel and Car Shops perform strictly maintenance type services. Waste oils are collected in drums and not discharged to sewers. Flow from this area is about 1 to 2 gpm and contains primarily slight traces of oil.

Excess wash waters constitute the small discharge from the Diesel and Car Wash Shop. A maximum of 3,000 GPD is discharged to the "C" system.

Analytical data are shown in Table 51.

TABLE 51
DIESEL AND CAR SHOP EFFLUENT
FLOW 3,000 GPD

	Average ppm
pH	9.6
Pht. Alkalinity	44.0
M.O. Alkalinity	164.0
Chlorides	28.0
Dissolved Solids	463.0
Suspended Solids	284.0
Phosphates	23.2
Oil	10.6

Structural Mill

The first step in rolling a structural section is to design the finish size, then to develop a method most suitable to produce these dimensions. All structural sections are preshaped on a two high Morgan mill. The structural mill is very flexible in that two mills fit on the same bed plate, one being a 23 inch mill and the other a 28 inch mill. Channels, angles and beams are rolled on the 23 inch mill. All wide flange beams, piling, and 2 center sills are rolled on the 28 inch mill. In the rolling of any section, the roll must be adjusted to perform the passes as designed. Untreated river water is used as process water at the structural mill. This water is used in the sluice way for scale removal, as mill hydraulic water for operating side guards, roll balancing, and high pressure sprays, coolant water for skid pipes in the reheat furnace, and as hot bed cooling water for structural shapes. Total discharges from this mill to the "C" system amount to about 9,500,000 GPD. Principal wastes in these waters include suspended solids and oils.

Analytical data are shown in Table 52.

TABLE 52
STRUCTURAL MILL EFFLUENT
FLOW 9,500,000 GPD

	High	Low ppm	Average	Lbs/Ton Rolled
pH	7.5	7.0	7.2	
Oil	125.0	80.0	93.0	29.83
Suspended Solids	480.0	38.0	154.0	49.40

SECTION VII

SEWER SYSTEM E

Sewer System E

Wastewaters that discharge to sewer system E originate from the following areas:

Basic oxygen steel making
Vacuum degassing
Continuous casting
Coal washer
Detinning plant

Basic oxygen steel making, vacuum degassing and continuous casting are integrated into one series of high tonnage operations with interconnected water recirculating systems. For this reason, these operations are discussed as one complex rather than as three individual operations.

Most of the wastewater from the galvanizing operations (sheet mill) is discharged to sewer system C, but a splitter box in the main sewer diverts a percentage of this wastewater to sewer system E. This percentage is dependent on the quantity of surface runoff water reaching the sewer. The galvanizing operations including the effects on sewer system E are discussed in System C.

A schematic of sewer system E is shown in Figure 5. Sampling points and flow rates for the various wastewater streams are indicated on the schematic. Approximately 400 samples taken at seven sampling points were analyzed selectively for the following:

1. pH
2. Alkalinity
3. Dissolved Solids
4. Suspended Solids
5. Total Iron
6. Chlorides
7. Sulfate
8. Phosphates
9. Zinc
10. Hexavalent Chrome

Basic Oxygen Steel Making, Vacuum Degassing and Continuous Casting

This facility integrates basic oxygen steel making, vacuum degassing and continuous casting into one connected series of high tonnage operations. A brief description of each operation follows below.

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Basic Oxygen Steel Making - This operation is commonly known as the basix oxygen process (B.O.P.) or basic oxygen furnace (B.O.F.). Molten iron from blast furnaces, scrap, lime and fluxes are charged into a large furnace and oxygen is injected at high velocities to burn out the impurities in the iron to produce molten steel. The oxygen reacts with the unwanted elements (carbon, silicon, phosphorus, and manganese) to form oxides which either leave the bath as gases, or combine with the lime to form a slag. The hot gases leaving the bath represent a sizeable amount of heat and to conserve this energy and to maintain a more favorable heat balance in the system, a boiler has been installed in the furnace stack. Furnace capacity is approximately 300 tons and the charge-to-tap time is approximately forty minutes. Upon completion of this forty minute cycle, the steel is tapped into a ladle after which it is either continuously cast into slabs, or teemed into ingots.

Vacuum Degassing - The purpose of the vacuum degassing operation is to remove dissolved gases (oxygen, nitrogen, and hydrogen) from the steel to improve its structure, thus making it more adaptable to slab casting. This is accomplished by exposing the molten steel to high vacuum. All heats which are continuously cast are vacuum degassed either completely or partially.

Continuous Casting - In this operation, molten steel is formed directly into slabs in one continuous process. The degassed molten steel is poured into a combination cooling chamber-mold and is withdrawn from the bottom of the mold as one continuous slab. The slab is pulled through the mold into a secondary cooling zone where it completely solidifies. A torch cuts the slab into desired lengths.

In summary, the basic oxygen furnace, vacuum degassing, and the continuous casting complex will convert blast furnace iron and scrap metal into steel, extract gases from the steel, and either continuously cast the steel into solid slab forms or teem the steel into ingots. The capacity of this facility is 3,600,000 tons of steel annually.

Process water to these operations is strained and distributed to five water systems within the complex: (1) B.O.P. dust system, (2) boiler feed water treatment, (3) cooling tower system, degassing and B.O.P., (4) continuous casting closed system, and (5) continuous casting open system.

B.O.P. Dust System

This water is used for scrubbing dust from the basic oxygen furnace exhaust gases. It is a recirculating system and the only makeup water required is for evaporation losses and blowdown. After the water leaves the scrubber system, large solids are separated from it in a classifier. The water is then further clarified in two thickeners and recirculated back to the scrubber. The underflow from the thickener is filtered. The filter cake and solids from the classifier (180 tons/day) are stored for future use. Blowdown of clarified water from the clearwell in this system amounts to 445 gallons per minute maximum.

Boiler Feed Water Treatment

River water is softened and used for boiler feed water. This process consists of four treatments: (1) hot softening, (2) filtering, (3) zeolite treatment, and (4) deaeration. The suspended and dissolved solids removed from the river water supply are filtered and disposed of as land fill. The amount of wastewater reaching the sewer from this system cannot be estimated because of intermittent regeneration, backwashing and rinsing of water softening equipment.

Cooling Tower System - Degassing and B.O.P.

The cooling tower water system is a recirculating installation in which the water is used for indirect cooling in the degassing and B.O.P. operations. The water after a cooling pass is returned to a cooling tower, cooled, and reused. The only make-up water required is for evaporation losses and for blowdown. Blowdown from this system is approximately 73 gallons per minute.

Continuous Casting Closed System

The continuous casting closed system is an indirect cooling system in which treated water is recirculated as the coolant in the continuous casting molds and associated equipment. The only make-up water needed is for evaporation losses and for blowdown. Blowdown from this system is 32 gallons per minute.

Continuous Casting Open System

The water in this system is used primarily for direct slab cooling on the continuous casting machine. Scale contamination in the water is removed by filters. The collected scale filter cake is processes and recharged into the steel making process. The filtrate water is cooled in cooling towers and reused. Blowdown water from this system is prefiltered and discharged at a rate of 242 gallons per minute.

The only other wastewater streams reaching the sewer in the basic oxygen furnace - vacuum degassing - continuous casting complex are (1) strainer backwash from the incoming raw water system (156 gpm), (2) vacuum pump seal water from the rotary drum filter (40 gpm), (3) miscellaneous pump seal water (flow not available) and (4) boiler water blowdown (450 gpm).

In summary, nine wastewater streams reach the sewer from this complex. It was impractical to sample all nine of these streams individually since some of them combine before reaching an accessible sampling point. Samples were taken at the following areas:

53 B.O.P. dust system thickener clearwell

54 Boiler feed water treatment plant

55 Cooling tower sump - the wastewater in this sump is a combination of five streams: (1) cooling tower system - vacuum degassing and B.O.P. (2) continuous casting closed system (3) continuous casting open system (4) strainer backwash from the incoming raw water and (5) boiler blowdown

56 B.O.P. pump seals, filter pump vacuum seal and floor drains

Analytical data are given in Tables 53 through 56 .

TABLE 53
B.O.P. DUST SYSTEM - THICKENER CLEARWELL
FLOW 641,000 GPD

	High	Low ppm	Average	Lbs/Ton Steel
pH	11.6	6.3	11.4	
Pht. Alkalinity	54.0	4.0	39.0	0.021
M.O. Alkalinity	106.0	22.0	67.5	0.036
Suspended Solids	361.0	36.0	122.0	0.065
Total Dissolved Solids	990.0	728.0	856.0	0.458
Total Iron	261.0	5.5	65.0	0.035

TABLE 54
BOILER FEED WATER TREATMENT PLANT
FLOW - INTERMITTENT

	High	Low ppm	Average
pH	11.5	11.3	11.4
Pht. Alkalinity	136.0	72.0	102.5
M.O. Alkalinity	200.0	146.0	173.3
Chlorides	63.0	32.0	48.9
Sulfates	480.0	312.0	410.0
Dissolved Solids	950.0	644.0	845.5
Suspended Solids	117.0	33.0	66.8
Phosphates	14.4	5.6	8.4

TABLE 55
COOLING TOWER SUMP
FLOW 1,862,000 GPD

	High	Low ppm	Average	Lbs/Ton Steel
pH	7.60	6.60	7.10	
M.O. Alkalinity	25.00	22.00	24.50	0.038
Chlorides	19.00	18.00	18.40	0.029
Sulfates	105.50	91.20	103.00	0.160
Dissolved Solids	261.00	238.00	242.50	0.376
Suspended Solids	50.00	8.00	31.00	0.048
Total Iron	6.12	0.42	2.90	0.004
Hexavalent Chrome	1.00	0	0.25	0.0004
Phosphates	12.00	2.40	4.90	0.0076
Zinc	0.58	0.16	0.42	0.0006

TABLE 56

B.O.P. PUMP SEALS, FILTER PUMP VACUUM SEAL AND FLOOR DRAINS

FLOW NOT AVAILABLE

	High	Low ppm	Average
pH	8.1	6.4	7.2
M.O. Alkalinity	22.0	6.0	15.3
Chlorides	48.0	16.0	29.3
Sulfates	139.0	101.0	120.0
Dissolved Solids	276.0	101.0	107.0
Suspended Solids	192.0	76.0	136.3
Total Iron	150.0	61.5	92.0
Zinc	6.6	1.2	4.6

Recommendations

The wastewaters from the basic oxygen furnace - vacuum degassing - continuous casting complex are not amenable to biological treatment and were not considered in the laboratory treatability studies. However, the following recommendations which could lead to improvement of present operations, are submitted for consideration and further study.

1. Recent investigations have shown that the present separation efficiency in the B.O.P. dust system thickeners may be increased by a factor of two through the use of magnetic flocculation. The economics of installing such a system should be investigated.

2. As an alternate to recommendation No. 1, laboratory studies with polymers indicate imrpovement in separation efficiency with the use of a highly charged high molecular weight synthetic organic polyelectrolyte. The zeta potential was run prior to testing and the -21 MV reading suggested a high charge anionic material which was related to jar testing results. Table 2 shows the results of the B.O.P. polymer studies.

3. In order to reduce the occurrence of suspended solids, a catch basin was installed below the gas cleaning system platform to collect the wastewaters resulting from pump seals, floor drains, etc. Presently, this water is discharged to the sewer. It is recommended that the water from this basin be pumped back to the thickener as indicated in Figure 12.

TABLE 2

BOP THICKENER INFLUENT

Jar No.	Polymer Conc. (ppm)	Polymer A Residual S.S. (mg)	Polymer A % S.S. Removal	Polymer C Residual S.S. (mg)	Polymer C % S.S. Removal	Polymer B1 Residual S.S. (mg)	Polymer B1 % S.S. Removal
1	0	72.8	0	72.8	0	72.8	0
2	0.05	27.7	61.9	21.0	71.0	13.4	81.6
3	0.1	10.5	85.6	17.0	76.6	15.1	79.2
4	0.5	4.4	94.0	2.2	96.9	18.7	74.3
5	1.0	6.2	91.5	1.3	98.2	17.8	75.5
6	2.0	5.2	92.8	2.3	96.8	20.8	71.4
7	5.0	9.02	87.6	8.0	89.0	15.2	79.0

Raw Sample Analysis

TSS 3500 mg/l
Alkalinity 26mg/l as $CaCO_3$
Harndess 169mg/l as $CaCO_3$
pH 6.6
Zeta Potential -21

A - High charged, high molecular weight

C - Medium charged, medium molecular weight

B1 - Medium charged, sulfonated polystyrene

TABLE 2 (Continued)

		Polymer					
		B2		B3		B4	
Jar No.	Polymer Conc. (ppm)	Residual S.S. (mg)	% S.S. Removal	Residual S.S. (mg)	% S.S. Removal	Residual S.S. (mg)	% S.S. Removal
1	0	72.8	0	72.8	0	72.8	0
2	0.05	24.1	66.9	64.8	11.0	66.9	8.1
3	0.1	14.2	80.4	48.1	34.0	67.6	7.2
4	0.5	6.5	91.0	20.1	64.2	24.4	66.5
5	1.0	8.0	89.0	6.6	90.9	9.4	87.2
6	2.0	10.9	85.0	6.4	91.2	9.4	87.2
7	5.0	17.3	76.2	5.8	92.0	9.8	86.5

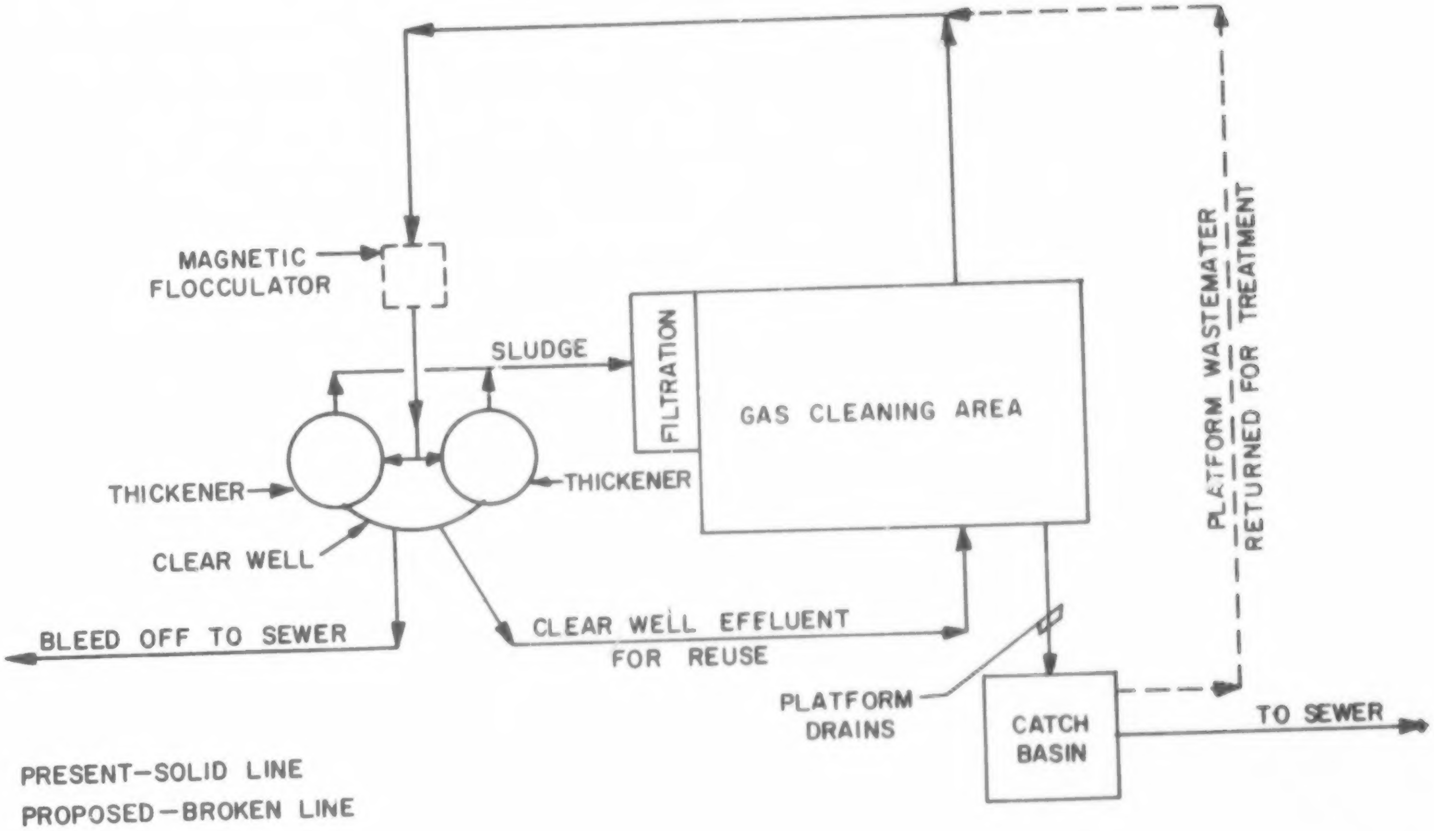
Raw Sample Analysis

TSS 3500 mg/l
Alkalinity 26mg/l as $CaCO_3$
Harndess 169mg/l as $CaCO_3$
pH 6.6
Zeta Potential -21

B2 - Medium charged sulfonated polystyrene - high molecular weight

B3 - Medium charged sulfonated polystryene - medium molecular weight

B4 - Medium charged sulfonated polystyrene - below medium molecular weight



BOP WASTE TREATMENT SYSTEM
FIGURE 12

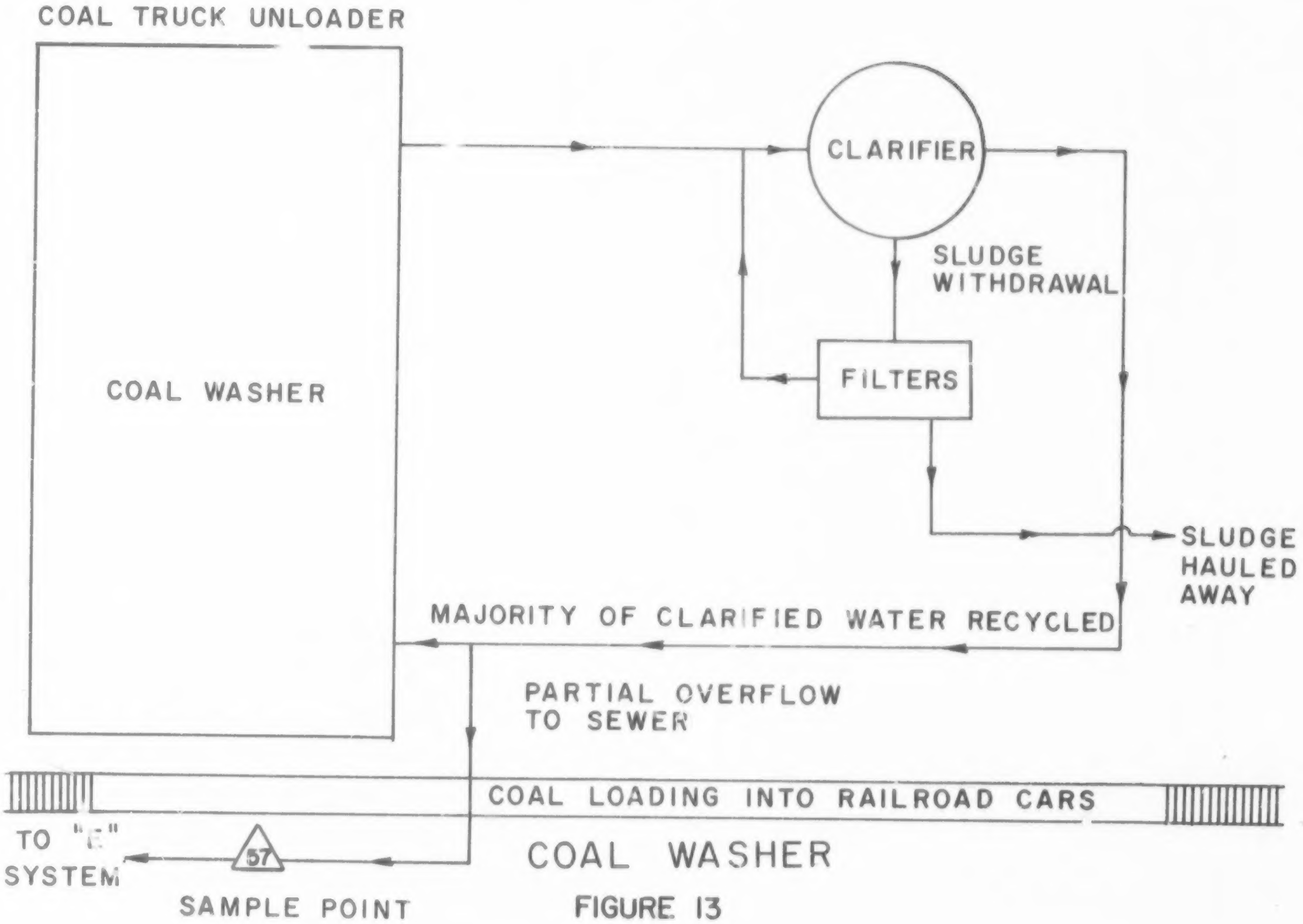
Coal Washer

Coal for the production of steam at the boiler house is washed prior to its use to remove foreign matter and reduce sulfur and ash content. Wastewater treatment and water reuse are practiced at the coal washer as shown in Figure 3. After the water is used to wash coal, it is pumped to a clarifier where it is chemically treated. The overflow from the clarifier is returned to the system for reuse while the clarifier for reprocessing, and the separated solids are hauled by truck to a landfill site for disposal. The only make-up water required in this system compensates for blowdown which amounts to approximately 50 gallons per minute. Approximately 1,800 tons of coal are washed daily in this operation.

Only one wastewater stream reaches the sewer in this operation as shown in Figure 13. Analytical data for this waste are given in Table 57 .

TABLE 57
COAL WASHER EFFLUENT
FLOW 72,000 GPD

	High	Low	Average	#/Ton Coal Cleaned
		ppm		
pH	9.2	7.8	8.5	
M.O. Alkalinity	412.0	100.0	286.5	0.086
Chlorides	50.0	26.0	40.0	0.012
Sulfates	413.0	96.0	157.0	0.047
Dissolved Solids	1626.0	710.0	1205.0	0.360
Suspended Solids	439.0	101.0	331.0	0.099
Total Iron	126.0	25.0	51.5	0.015
Aluminum	4.1	1.5	2.3	0.0007



COAL WASHER

FIGURE 13

Recommendations

The wastewater from the coal washer is not amenable to biological treatment and was not considered in the laboratory treatability studies. The waste treatment facilities at the coal washer are operating satisfactorily, but it appears that the chemical dosage demand is quite high. It is recommended that a study be made on the chemical treatment system to determine the potential for reduced treatment costs.

Detinning Plant

The main function of the detinning plant is to reclaim tin from tinplate scrap and electrolytic sodium fluorostannate acid sludge.

Tin is reclaimed from tinplate scrap by placing it in a drum containing sodium nitrate caustic soda. The solution reacts with the tin to form sodium stannate. The excess sodium stannate precipitates out of solution and collects on the bottom of the tank. The drum is drained and rinsed, and the scrap steel is reused in the basic oxygen furnace. Sodium stannate precipitate accumulates in the tank and is recovered. The stannate is subjected to a sulphuric acid treatment which converts it to stannic hydroxide. This product is filtered, dried, mixed with anthrcite coal, and reduced to metallic tin.

1) $Na_2SnO_3 + H_2SO_4 + H_2O \longrightarrow Sn(OH)_4 + Na_2SO_4$

2) $Sn(OH)_4 \longrightarrow SnO_2 + 2H_2O$

3) $SnO_2 \cdot 2H_2O + C \longrightarrow Sn + CO_2 + H_2O$

Tin is reclaimed from the electrolytic sodium flurostannate sludge by reacting with sodium carbonate to form stannic hydroxide. The stannic hydroxide is then reduced to metallic tin as previously stated.

$$Na_2SnF_6 + 2Na_2CO_3 + 4H_2O \longrightarrow Sn(OH)_4 + 6NaF + 2H_2CO_3$$

Wastewaters in the detinning process originate from the filtering and washing operations and exit from the plant in two streams as shown in Figure 5. Analytical data for these waste streams are given in Tables 58 and 59

TABLE 58

DETINNING PLANT; NO. 1 MANHOLE

FLOW - 72,000 G.P.D.

	High	Low ppm	Average
pH	9.30	7.80	9.00
Pht. Alkalinity	352.00	4.00	108.50
M.O. Alkalinity	1072.00	64.00	540.60
Chlorides	422.00	24.00	128.10
Sulfates	6996.00	110.40	1490.50
Suspended Solids	2397.00	64.50	390.80
Total Iron	14.20	3.70	6.90
Cyanide	0.96	0.46	0.73
Tin	1440.00	9.70	191.50
Total Chrome	0.15	0	0.06

TABLE 59

DETINNING PLANT; NO. 2 MANHOLE

FLOW 36,000 G.P.D.

	High	Low ppm	Average
pH	10.9	7.1	8.6
M.O. Alkalinity	3850.0	76.0	1932.0
Chlorides	275.0	50.0	135.8
Sulfates	14400.0	1080.0	5580.0
Suspended Solids	1287.0	98.0	633.0
Total Iron	36.6	2.0	13.3
Total Chrome	6.4	0	1.8
Fluorides	920.0	430.0	571.2
Tin	540.0	24.8	137.8
Cyanide	6.5	0.13	3.3

Recommendations

The detinning operation is in essence a waste treatment process and it appeared to be closely controlled. Effluent volume from the operations amounted to about 75 gpm. These wastes were introduced in the treatability studies and were found to be amenable to biological treatment.

Section VIII

Sewage Treatment Plant

Data Acquisition Evaluation

The city of Weirton operates sewage treatment facilities under the direction of the Weirton Sanitary Board. The facilities were designed in 1957 by Alden E. Stilson & Associates, Limited, of Columbus, Ohio, to provide primary degree removal with chlorination for a design population of 38,700 in the year 1980. The average daily design flow through the plant was 4,000,000 gallons per day. The sewage treatment facilities consist of grit removal, screening and grinding, raw sewage pumping, preaeration, primary settling, chlorination, separate sludge digestion, and disposal of the sludge by vacuum filtration with the dried sludge trucked to waste. A schematic flow sheet of the Weirton sewage treatment plant is shown on Figure 14. The dimensions and capacities or volumes of the major components of the treatment plant are listed in Table 3.

Undoubtedly the flows and population increase anticipated by the design engineers have not developed, as the average daily flow through the sewage plant is on the order of 1.25 mgd. As a result, only one-half of the treatment facilities are in use.

To determine the volume of industrial water that can be discharged to the sewage plant, daily flow rates for the past three years have been studied. These were compiled on a monthly basis and the ranges and average daily flows for each month are shown on Table 4 for a three year period beginning November 1, 1967, and ending October 31, 1969. The mean daily flow for each of these respective calendar years (November to October) was 1.062, 1.330, and 1.278 mgd. The three year mean daily flow was 1.223 mgd. Daily flows during this period ranged from a low of 0.180 mgd to a high of 2.524 mgd. Only the volume of sewage flowing through the plant is recorded, and on those days when the volume is very low, such volumes are indicative that sewage is being bypassed to the Ohio River.

Laboratory Control

Laboratory control of the plant's operation consists of daily analyses of the raw and treated sewage for pH, dissolved oxygen, total, suspended and settleable solids,

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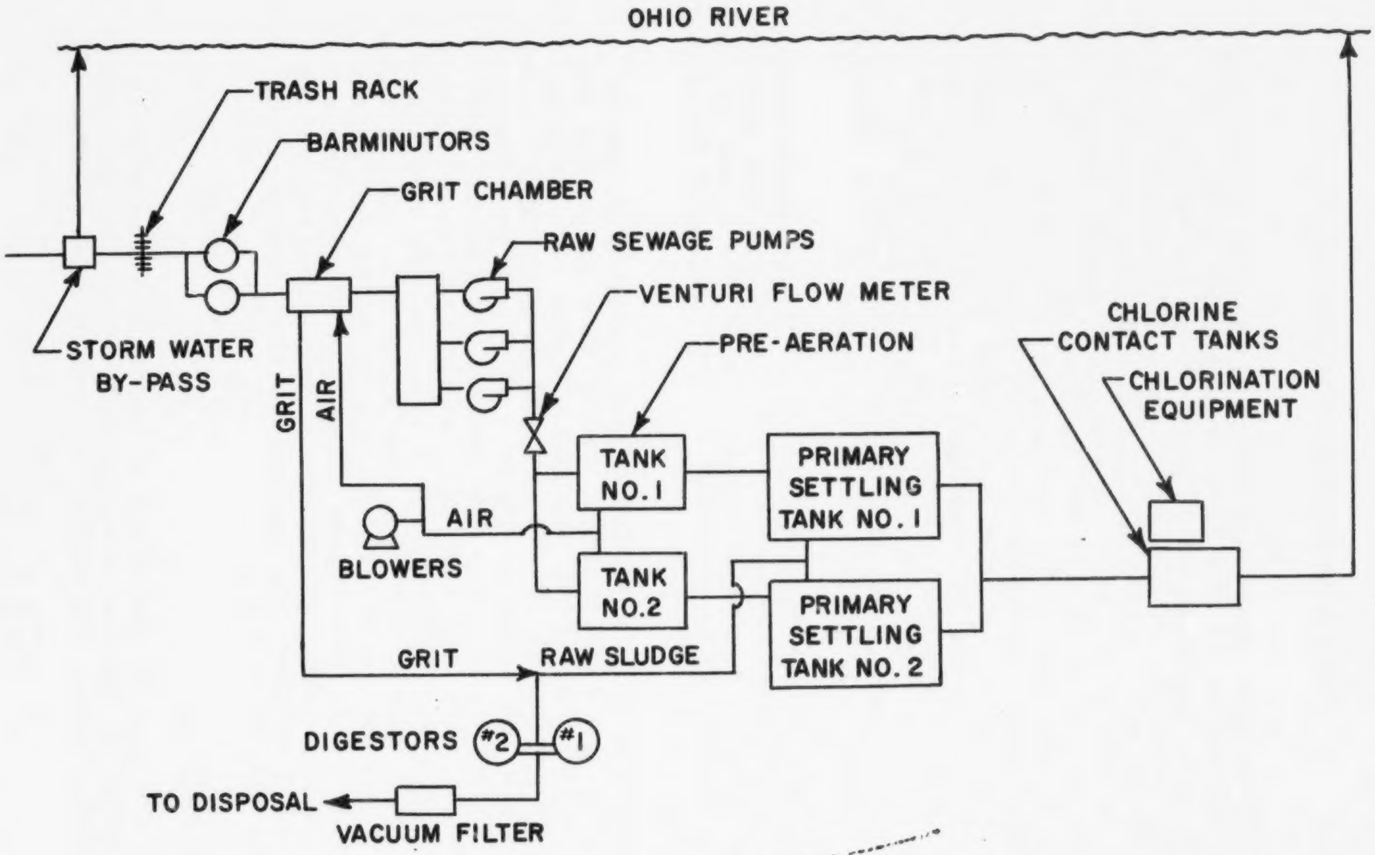


SCHEMATIC FLOWSHEET PRIMARY SEWAGE TREATMENT PLANT

FIGURE 14

TABLE 3

PHYSICAL SIZE OF MAJOR FACILITIES
WEIRTON SEWAGE TREATMENT PLANT

Unit	No.	Dimensions	Capacity or Volume
Comminutor	2	-	6.5 mgd
Grit Chamber	1	16'-6" x 12'-0" x 10'-2" SWD	15,250 gallons
Raw Sewage Wet Well		33'-0" x 20'-0" x 8'-0" SWD	23,900 gallons
Raw Sewage Pumps	3		No. 1 - 2000 gpm No. 2 - 3500 gpm No. 3 - 2000 gpm
Preaeration Tanks	2	35'-0" x 16'-0" x 9'-7" SWD	41,200 gals. each tank
Primary Sedimentation Tanks	2	96'-6" x 33'-0" x 9'-5" SWD	214,380 gals. each tank
Chlorine Contact Tank	1	28'-0" x 18'-0" x 15'-0" SWD	56,540 gallons
Digestors	2	55'-0" dia x 23'-0"	

TABLE 4

COMPILATION OF DAILY RECORD FLOWS OF WEIRTON SEWAGE PLANT THREE-YEAR PERIOD NOVEMBER 1, 1967 THROUGH OCTOBER 31, 1969

	1967		1968		1969	
	Monthly Flow Range, mgd	Avg. Daily Flow, mgd	Monthly Flow Range, mgd	Avg. Daily Flow, mgd	Monthly Flow Range, mgd	Avg. Daily Flow, mgd
Nov.	0.645-1.214	1.001	0.395-1.414	0.959	1.107-1.600	1.308
Dec.	0.775-1.608	1.135	0.746-2.050	1.571	1.056-1.813	1.455
Jan.	0.772-1.439	0.970	0.505-1.873	1.431	1.046-1.679	1.444
Feb.	0.770-1.400	1.066	0.378-1.651	1.330	1.090-1.640	1.357
March	0.453-1.615	0.957	1.320-2.340	1.815	0.897-1.589	1.375
April	0.485-1.350	0.904	0.388-2.524	1.766	0.344-1.753	1.262
May	0.590-1.245	1.045	0.859-1.772	1.283	0.902-1.565	1.176
June	0.900-1.170	1.034	0.690-1.276	0.872	0.851-1.248	0.025
July	0.250-1.130	0.904	0.230-1.623	1.129	0.911-1.310	1.095
August	0.973-1.633	1.329	0.870-1.572	1.280	0.180-1.470	0.991
Sept.	0.328-1.420	1.151	0.420-1.350	1.193	1.210-1.659	1.436
Oct.	1.100-1.578	1.253	1.140-1.610	1.329	1.030-1.579	1.410
Year Mean:		1.062		1.330		1.278
Yearly Range	0.250-1.633		0.230-2.524		0.180-1.813	

3 Year Mean: 1.223 mgd

5-day biochemical oxygen demand (BOD), and temperature. The total daily sewage flow, effluent chlorine residual and volume of sludge pumped to the digesters are also recorded. Daily settleable and suspended solids and BOD records have been compiled on a monthly basis for the period November, 1966, through October, 1969, and are listed on Tables 5, 6 and 7, respectively. The plant's efficiency based upon these three parameters can be summarized in the following Tables:

TABLE 5

COMPILATION OF DAILY RECORDED SETTLEABLE SOLIDS ANALYSES THREE YEAR PERIOD NOVEMBER 1, 1967 THROUGH OCTOBER 31, 1969 SEWAGE TREATMENT PLANT, WEIRTON, WEST VIRGINIA

SETTLEABLE SOLIDS, IN ml/l

	1967 Monthly Average			1968 Monthly Average			1969 Monthly Average		
	Raw	Final	Reduction	Raw	Final	Reduction	Raw	Final	Reduction
Nov.	4.2	0.7	83.3%	4.9	0.4	91.8%	5.8	0.6	89.7%
Dec.	3.8	0.7	81.6%	4.3	0.8	81.4%	4.3	0.7	83.7%
Jan.	4.5	0.3	93.3%	4.6	0.7	84.8%	4.6	0.8	82.6%
Feb.	4.1	0.6	85.4%	4.0	0.9	77.5%	5.4	0.5	90.7%
March	2.5	0.2	92.0%	3.4	0.6	82.4%	5.4	0.8	85.2%
April	2.7	0.3	88.9%	3.6	0.7	80.6%	4.6	0.8	82.6%
May	3.7	0.4	89.2%	3.3	0.6	81.8%	5.1	0.6	88.2%
June	5.0	0.8	84.0%	4.4	0.6	86.4%	5.6	0.4	92.9%
July	5.3	0.8	84.9%	5.2	1.0	80.8%	5.1	0.7	86.3%
August	5.8	0.5	91.4%	5.4	0.4	92.6%	4.2	0.3	92.9%
Sept.	5.3	0.4	92.5%	7.0	0.5	92.9%	6.4	0.8	87.5%
Oct.	5.3	0.7	86.8%	6.6	0.4	93.9%	5.3	0.9	83.0%
Yearly Mean:	4.4	0.5	87.7%	4.7	0.6	86.6%	5.2	0.7	87.2%

TABLE 6

COMPILATION OF DAILY RECORDED SUSPENDED SOLIDS ANALYSES THREE YEAR PERIOD NOVEMBER 1, 1967 THROUGH OCTOBER 31, 1969 SEWAGE TREATMENT PLANT, WEIRTON, WEST VIRGINIA

SUSPENDED SOLIDS, IN mg/l

	1967 Monthly Average			1968 Monthly Average			1969 Monthly Average		
	Raw	Final	Reduction	Raw	Final	Reduction	Raw	Final	Reduction
Nov.	114	42	63%	126	59	53%	141	64	55%
Dec.	-	-	-	115	61	47%	116	59	49%
Jan.	138	58	58%	126	51	60%	100	46	54%
Feb.	116	58	50%	100	62	38%	139	55	60%
March	90	43	52%	101	66	35%	123	62	50%
April	84	42	50%	97	54	44%	93	54	42%
May	80	32	60%	108	77	29%	112	49	56%
June	109	61	44%	115	44	62%	123	55	55%
July	138	75	46%	146	59	60%	93	42	55%
August	150	66	56%	199	72	71%	152	65	57%
Sept.	161	67	58%	136	37	73%	119	66	45%
Oct.	158	62	61%	148	49	67%	-	-	-
Yearly Mean:	122	55	55%	126	58	54%	119	56	53%

TABLE 7

COMPILATION OF DAILY RECORDED B.O.D.* ANALYSES
THREE YEAR PERIOD NOVEMBER 1, 1967 THROUGH OCTOBER 31, 1969
SEWAGE TREATMENT PLANT, WEIRTON, WEST VIRGINIA

BIOCHEMICAL OXYGEN DEMAND (B.O.D.), IN mg/l

	1967 Monthly Average			1968 Monthly Average			1969 Monthly Average		
	Raw	Final	Reduction	Raw	Final	Reduction	Raw	Final	Reduction
Nov.	215	141	34%	224	118	47%	198	116	41%
Dec.	196	120	39%	197	119	40%	169	104	38%
Jan.	205	138	33%	211	138	35%	179	107	40%
Feb.	194	108	44%	166	117	30%	196	119	39%
March	102	65	36%	216	157	27%	215	139	35%
April	134	87	35%	213	129	39%	179	114	36%
May	133	71	47%	182	115	37%	156	96	38%
June	194	125	36%	207	102	51%	184	109	41%
July	162	94	42%	218	121	44%	149	95	36%
August	216	164	24%	229	129	44%	175	122	30%
Sept.	213	140	34%	218	111	49%	199	130	35%
Oct.	225	142	37%	196	115	41%	212	132	38%
Yearly Mean:	182	116	36%	206	123	41%	184	115	37%

*B.O.D. = Biochemical Oxygen Demand

Over a three year period, these parameters of efficiency show the operation and performance of the sewage treatment plant to be faily consistent. The performance of this plant is typical of other primary plants, even though the one primary settling tank in use is operating at 65% of its design flow of 2.0 mgd. (Table 8).

The existing primary treatment plant was designed for an average daily flow of 4.0 mgd. The State of West Virginia's Department of Health follows the recommended design practice of the Ten States Standards[1]. These design criteria change somewhat when using the primary treatment facilities in a secondary treatment process. The capacities of the existing facilities are compared to the design parameters for both primary and secondary treatment in Table 9 to show the limiting capacity (flow) for expansion. Based upon this evaluation, the limiting unit would be the chlorine contact tank at a flow of 5.0 mgd. Additional chlorine contact capacity could be provided by enlarging the existing unit or adding another tank during plant expansion. Since the preaeration tanks are not necessary for expansion to secondary treatment, the next limiting facilities are the sedimentation tanks at a flow of 6.4 mgd.

Secondary Treatment Processes

There are two basic, biological treatment processes to be considered for expansion of the existing Weirton sewage treatment facilities to provide secondary treatment; i.e., activated sludge or trickling filters. A third, physical treatment process similar to the "Chemical/Physical Wastewater Treatment Process" recently patented by the Calgon Corporation should also be considered because of the nature of the industrial wastes that are being considered for discharge to the sewage facilities for treatment.

Activated Sludge Process[2]

There are many variations of the activated sludge process

1. "Standards for Sewage Works," Upper Mississippi River Board of Public Health Engineers and Great Lakes Board of Public Health Engineers, revised July, 1954.

2. "Sewage Treatment Plant Design", Manual of Practice No. 8, Water Pollution Control Federation and the American Society of Civil Engineers, 1959.

TABLE 8

WEIRTON SEWAGE TREATMENT PLANT
SUMMARY OF PLANT PARAMETERS OF EFFICIENCY

YEARLY MEAN PERCENTAGE OF REDUCTION

	Settleable Solids % Reduction	Suspended Solids % Reduction	Biochemical Oxygen Demand % Reduction
1967	87.7%	55%	36%
1968	86.6%	54%	41%
1969	87.2%	53%	37%
3 Year Mean	87.2%	54%	38%

TABLE 9

COMPARISON OF UNIT CAPACITY DURING PRIMARY AND SECONDARY TREATMENT WEIRTON SEWAGE TREATMENT PLANT

Unit	Design Parameter	Primary Treatment Required or Recommended	Primary Treatment Provided at 4.0 mgd Flow	Secondary Treatment Required or Recommended	Secondary Treatment Limiting Flow
Comminutor	None	-	6.5 mgd each	-	6.5 mgd
Grit Chamber	Velocity	0.75-1.25 fps	0.04 fps	Same	75.0 mgd
	Detention	1.1 minutes	5.49 minutes	Same	20.0 mgd
Preaeration	Detention	20-30 minutes	29.7 minutes	Same	5.9 mgd
	Aeration Rate	0.0-0.2 ft^3/gal	0.2 ft^3/gal	Same	8.0 mgd
Sedimentation Tanks	Surface Settling Rate	600-800 gpd/ft^2	628 gpd/ft^2	1000 gpd/ft^2	6.4 mgd
Chlorine Contact Chamber	Peak Hourly Flow, or peak Pumping Rate	15 minutes	20 minutes at 2000 gpm	Same	5.0 mgd

for biological waste treatment. Although varying in detail, they essentially consist of aeration tanks with their aerating and agitating facilities; the final settling tanks with their sludge withdrawal facilities; and pumps for returning the activated sludge from the settling tanks to the aeration tanks. Preliminary treatment to remove grit and coarse solids ahead of the aeration tanks is usually accomplished with primary sedimentation tanks. The activated sludge is agitated and aerated. The activated sludge is subsequently separated from the treated sewage (mixed liquor) by sedimentation, and wasted or returned to the process as needed. The treated sewage overflows the weir of the settling tank in which separation of the sludge takes place. The "activated" sludge is a floc that is produced by the growth of bacteria and other organisms in raw or settled sewage in the presence of dissolved oxygen (aeration tanks). The floc is permitted to accumulate or concentrate by continually collecting it in settling units and returning it to the aeration tank.

The conventional activated sludge process has long been used in treating domestic wastes and to some extent in treating industrial wastes. This process is capable of producing a somewhat higher degree of treatment, 90 to 95% BOD reduction, and a clearer effluent than most other biological oxidation processes.

Completely mixed activated sludge processes have found increasing popularity for use on industrial wastes. In general, industrial wastes are more highly contaminated than domestic wastes and, more importantly, are often subject to sudden, sharp increases in contamination. It is frequently claimed that the conventional activated sludge process is easily upset by industrial wastes and is incapable of handling shock loads. This reputation may be due largely to inadequate design and/or faulty operation. Well-designed and operated activated sludge plants have effectively handled high proportions of various industrial wastes. For those systems where shock loadings of industrial wastes can be expected, the use of combined mechanical and diffused aeration devices is preferred over straight diffused aeration in order to completely mix the incoming raw waste with the contents of the aeration tank as thoroughly as possible.

Trickling Filter Processes

A trickling filter or biofilter is a fixed bed of rocks, slag, or plastic media over which the wastewater flows and is contacted with a microbial slime which has formed into a thin layer or film covering the bed media. Aerobic conditions are maintained by natural draft air currents flowing through the bed.

In actuality, the wastes are not filtered, but are absorbed by the microbial slime. Air is diffused into the slime layer to furnish oxygen for biochemical synthesis, and auto-oxidation or endogenous respiration takes place, releasing carbon dioxide water, and other oxidized end products. The net new growth of microbial sludge causes the slime layer to thicken. As the layer becomes thicker the outer portion will eventually slough off.

There are many variations of the basic trickling filter process. When the system is used for treating domestic wastes or combinations of domestic and industrial wastes, primary sedimentation is employed. In the conventional process, the primary settled effluent is passed through the trickling filter and into a final or secondary settling tank which removes the settleable solids sloughed from the filter. Without any recirculation of the clarified plant, the process is termed low rate or standard rate.

Most trickling filter systems constructed today employ the high rate design. The difference between low rate and high rate filters is in the hydraulic loading. Most high rate filters utilize recirculation, which is recycling of filter effluent through the filter. Variations in the basic process begin with varying recirculation ratios; whether the recycled filter effluent is returned to the primary settling tank influent or to the filter influent; variations as to the recycle methods to two filters in series, use of intermediate settling tanks, etc.

Trickling filters are applicable for secondary treatment of domestic sewage and mixtures of domestic and industrial wastes which are susceptible to aerobic biologic processes. They are capable of providing adequate treatment of such wastes where the production of a plant effluent of 20 to 30 mg/l of BOD is acceptable, assuming normal loadings. Trickling filters are the most versatile of the biologic treatment processes, and very dependable in performance.

Activated Carbon Wastewater Treatment Process

The use of granular activated carbon to remove dissolved organic matter from wastewater has been successfully applied to many industrial wastes. Demonstration of this process by the U. S. Environmental Protection Agency at Pomona, California, and Lake Tahoe, Nevada, have shown its application for tertiary treatment of domestic wastes. The use of activated carbon system to provide BOD removals equal to secondary biological treatment was recently demonstrated by the Calgon Corporation at the Cuyahoga County Waste Treatment Plant in Rocky River, Ohio.

The process is of interest in the Weirton situation because of the possible variations of dissolved organic materials under consideration for combined domestic and industrial waste treatment in the city sewage plant. The patented Calgon process consists of primary sedimentation with the addition of chemical coagulants to increase suspended solids removal. The clarified wastewater is then passed through "contactors" which are vertical columns containing beds of granular, activated carbon. The carbon adsorbs dissolved matter and also serves to filter suspended solids. Since this is a physical process rather than a biological one, the system will be unaffected by sudden changes in influent wastewater quality or by toxic substances. Such a system can be expected to provide consistent BOD removals of 90 to 95%.

Design Parameters for Demonstration Plant

Design of the Demonstration Plant is to be included in Phase II of the original three phase project. However, based on the treatability evaluation and the present sewage plant facilities, some basic preliminary design criteria may be established. If the existing primary settling tanks are utilized as primary tanks, the design of the surface settling rate would be <600 gpd/ft^2. If these tanks are to be used as intermediate tanks, the surface settling rate would be <1000 gpd/ft^2.

Design criteria for the aeration tanks is based on an applied loading of 35 pounds BOD/1000 ft^3. Detention time is in the order of six (6) hours with tank depths approximating ten (10) to fifteen (15) feet. If more than two (2) aeration tanks are required, the existing preaeration tanks may be put into service. Air requirements to supply the necessary two (2) ppm of dissolved oxygen are approximately 1500 cu. ft. air/lb. BOD.

Return sludge pump capacity would be in the magnitude of 50% of the design flow to optimize the mixed liquor suspended solids. The final settling tanks would be designed to achieve a surface settling rate of <800 gpd/ft^2. The design parameters of the treatment process would be such so as to provide greater than a 90% removal of BOD and suspended solids.

Cost Estimates for Expansion to Secondary Treatment

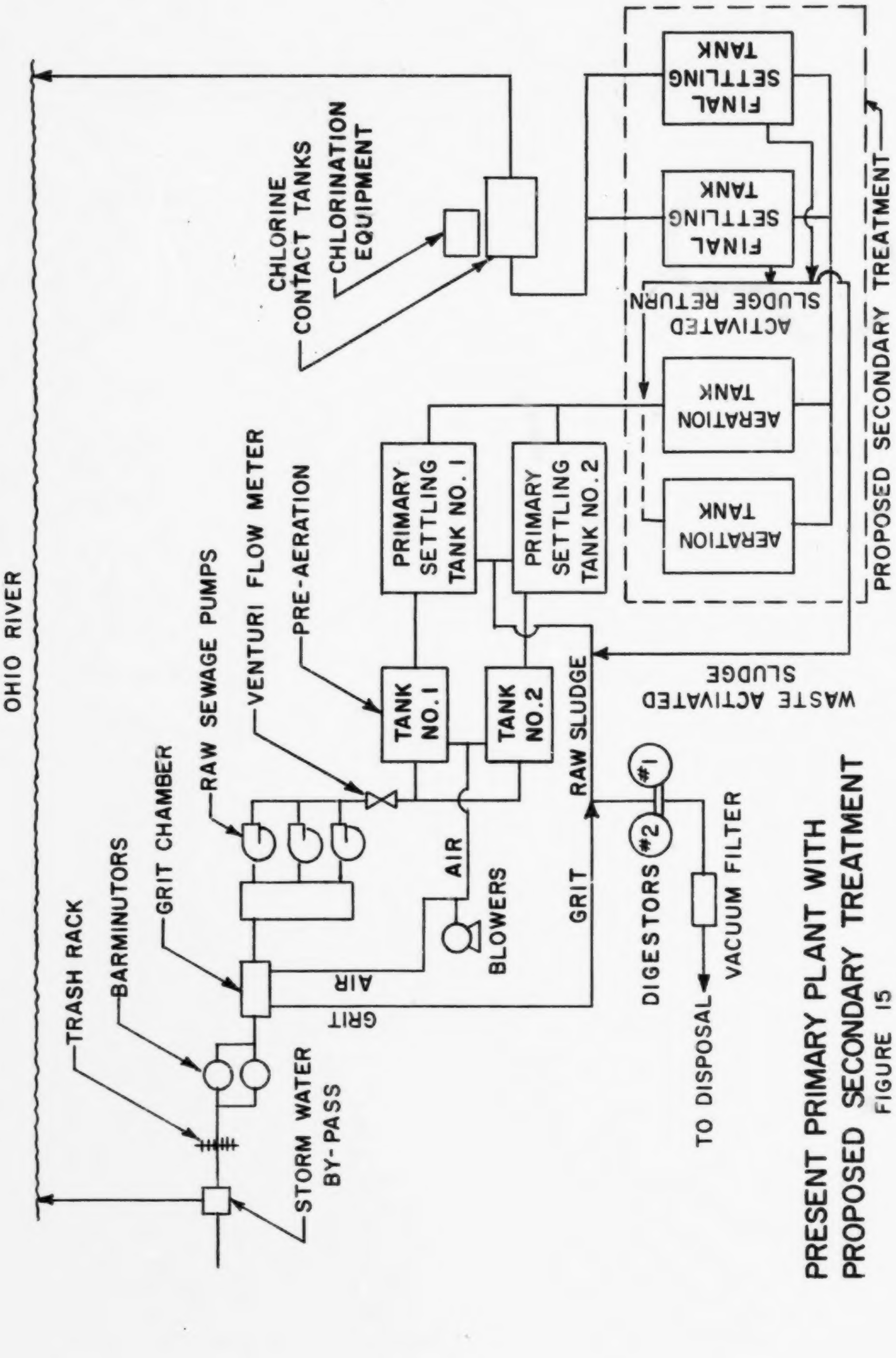
Construction costs have been estimated for expansion of the existing Weirton Sewage Treatment Plant to provide secondary treatment. Cost estimates are given only for the activated sludge process. Construction cost estimates for expansion to trickling filtration will be about the same as activated sludge; however, costs for the activated carbon process can be expected to be 10% to 20% lower. Operating costs for the activated sludge process at Weirton are estimated to increase the present operating costs by 50%. Operating costs for the trickling filtration and activated carbon processes are estimated to increase present operating costs by 40% and 60% respectively.

Table 10 shows the construction cost estimates for expansion facilities for combined sewage and industrial wastes at a flow of 4.5 mgd. Figure 15 shows the proposed layout for expansion of the present primary treatment plant.

TABLE 10

WEIRTON SEWAGE TREATMENT PLANT
SECONDARY TREATMENT EXPANSION
CONSTRUCTION COST ESTIMATE

UNIT	DESIGN FLOW RATE 4.5 MGD
Conventional Activated Sludge Aeration Tanks	$275,000
Final Clarifiers with Return Sludge Pumping Facilities	150,000
Interunit Piping	175,000
Electrical, Plumbing and Heating	75,000
Contingency at 20%	135,000
Engineering and Project Supervision	80,000
TOTAL ESTIMATED CONSTRUCTION COST	$890,000



PRESENT PRIMARY PLANT WITH PROPOSED SECONDARY TREATMENT

FIGURE 15

SECTION IX

SEWER SYSTEM DATA AND EVALUATION

The city of Weirton tied together the existing sanitary sewer system with an interceptor system when the sewage treatment facilities were constructed. Several areas in the Weirton Steel Division are under consideration for disposal of wastewaters to the city sewage treatment facilities. These include the coke plant area, palm oil recovery, sheet mill, tin mill, and the hot strip mill.

The coke plant is in an area where the city interceptor begins. Sanitary wastes from both the coke plant and the steel works areas presently flow by gravity to the city's Fifth Street lift station. The King's Creek, Kings's Bowl, and Weircrest areas of the city also drain to this station.

Since most of the wastes considered for co-treatment emanate from the coke plant, an in-plant economic evaluation should be made for construction of internal sewers and related facilities. Consideration should also be given to costs for an equalization basin or similar type holding capacity. It would appear that holding capacity of eight (8) to twelve (12) hours would be required, which would entail the installation of a 500,000 to 1,000,000 gallon tank or basin.

The lift station is equipped with two, 1,000 gpm pumps. Observation of the operation of these pumps indicates an average daylight pumping rate of 500 to 750 gpm. Much of the time both pumps are operating, presumably at a total pumping rate of 2,000 gpm. As a first estimate, the lift station has the capacity of an increase in flow of 1,250 gpm (1.8 mgd). Since the 14 inch cast iron force main from the lift station can handle larger flows than 2,000 gpm, the installation of larger pumps is a possibility; however, the capacity of the gravity interceptor must first be determined.

The force main discharges into a 21 inch reinforced interceptor installed on a slope of 0.5 ft/100 ft. Using a roughness coefficient of 0.013 in the Manning formula, this segment of the interceptor has a capacity to convey 7.5 mgd when flowing full. Standard sanitary engineering design is to provide 250% of design flow for peak flow and infiltration in interceptors. Therefore, this segment of the interceptor has a capacity for 3.0 mgd, or approximately the capacity of the lift station.

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The 21 inch portion of the interceptor enlarges to 24 inches on a slope of 0.4 ft/100 ft. This segment has a capacity for 9.0 mgd when full or 3.9 mgd at standard design flow. Below this, the interceptor enlarges to 30 inches, 36 inches, and 48 inches. The relevant data for this interceptor from the lift station to the sewage plant is summarized in Tables 11 and 12.

Presently, the limiting capacity in the interceptor sewer is approximately 1.0 to 1.5 mgd into the Fifth Street lift station. The force main discharges into a 21 inch segment of the interceptor. Although standard design practice would place the capacity of this sewer at 3.0 mgd, the determination of the actual peak flows in this sewer may show that it has a higher "safe" reserve capacity than the present estimate of 1.6 mgd. Similar determinations may also be necessary in the larger downstream portions of the interceptor.

The 21 inch and 24 inch portions of the interceptor are constructed of vitrified clay pipe, and the larger diameter portions of reinforced concrete pipe. Vitrified clay is very resistant to acids, alkalis and other corrosive chemicals. Concrete pipe on the other hand can be corroded by acids and sulfide gas. The industrial wastes under consideration for discharge into the Weirton sanitary system basically consist of acid scrubber rinses, tin mill finishing rinses, and oil waters from the palm oil treatment plant and Weirlite lines. Analyses of these wastewaters during this study found them to be in the neutral pH range and not to contain sulfides.

Other wastes under consideration are those from the coke plant. These waters do contain sulfides, but it is believed that they will react with soluble iron from the acid rinses to form insoluble ferrous sulfate and not create any corrosion problems. As a protective measure, it is recommended that either the wastewaters or the interceptor be continuously monitored for pH to prevent against an unnoticed acid condition occurring.

The investigation of the sewer system indicated that selected steel plant wastes could be handled in the main city sewer system, but that an individual plant study should be made on internal sewer costs.

TABLE 11

INTERCEPTOR SEWER DESIGN DATA

WEIRTON, WEST VIRGINIA

Interception Segment	Material of Construction	Diameter
Fifth Street Lift Station	Cast Iron	14"
No. 3-A	Extra Strength V.C.P.	21"
	Extra Strength V.C.P.	24"
No. 1	R.C.P., R.C.C.P. 2 Extra Strength R.C.C.P.	30"
	R.C.P.	36"
	R.C.P., R.C.C.P., 2 Extra Strength R.C.C.P.	48"

R.C.P. - Reinforced Concrete Pipe

R.C.C.P. - Reinforced Concrete Culvert Pipe

V.C.P. - Vitrified Clay Pipe

TABLE 12

INTERCEPTOR SEWER DESIGN DATA
WEIRTON, WEST VIRGINIA

INTERCEPTION SEGMENT	SLOPE FT/100FT	CAPACITY WHEN FULL*	ALLOWABLE CAPACITY	PROBABLE SAFE RESERVE CAPACITY	NEARBY OR ADJACENT WEIRTON STEEL FACILITIES
Fifth Street Lift Station	-	>2.9 mgd	-	1.5 mgd	Coke Plant Area and Tin Mill
No. 3-A	0.5	7.5 mgd	3.0 mgd	1.6 mgd	Cold Mill and Finishing and Sheet Mill
	0.4	9.0 mgd	3.8 mgd	2.3 mgd	Detinning Mill and Palm Oil Recovery
No. 1	0.4	17.5 mgd	7.0 mgd	5.0 mgd	
	0.2	20.0 mgd	8.0 mgd	-	
	0.6	70.0 mgd	28.0 mgd	-	

*At n = 0.015 in Manning's Formula

Section X

Laboratory Treatability Studies

Laboratory treatability studies were undertaken to evaluate the biological treatability of various combinations of the subject industrial wastes admixed with varying amounts of municipal sewage. The two prime considerations in the laboratory studies were:

1. The ability of microorganisms to acclimate and subsequently degrade waste constituents.

2. Possible deleterious effects of the various steel mill wastes on the biological system.

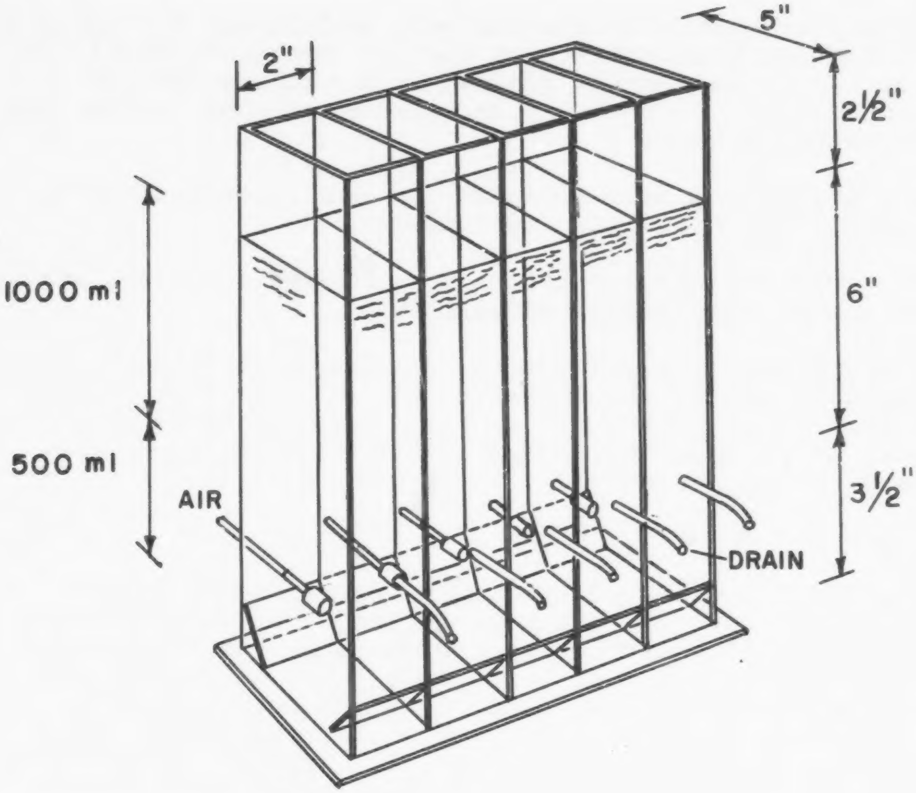
Two basic laboratory methods were evaluated for studying the treatability of industrial wastes by biological processes. There were continuous units such as those proposed by Ludzack, Busch and Renn, and fill-and-draw units such as proposed by Symons, et.al.

Phase I

For the initial phase of the study the method of Symons, et.al., appeared to be the best choice. The simplicity of these units allowed several to be operated simultaneously. This consideration was of prime importance since many different waste streams were candidates for cotreatment in many different combinations. Two, five compartment units of the type proposed by Symons et.al., (Figure 16) provided for ten simultaneous runs for the determination of treatability.

The following waste streams were used in the laboratory studies:

1. Raw ammonia liquor
2. Ammonia still waste
3. Absorber barometric condenser effluent
4. Benzol cooling tower bleed
5. Benzol sump
6. Final cooler bleed
7. Elliott strainer backwash
8. Tin mill electroplating line discharge
9. Pickle line scrubber rinses
10. Galvanizing mill wastes
11. Detinning plant wastes



BATCH-FED PILOT PLANT

FIGURE 16

12. Weirlite mill effluent
13. Palm oil recovery effluent
14. Municipal sewage

The first tests conducted by fill-and-draw techniques were designed to provide information on the acclimation times and degrees of toxicity or degradability of specific wastes. In this test, the bacteriological cultures were first acclimatized over a period of 2 weeks to feed upon sodium benzoate, phenol, cyanide and a phenol/cyanide mixture. A particular waste material was then added to each of the above four systems in increasing concentrations accompanied by a corresponding decrease in base feed (phenol, cyanide, sodium benzoate) to maintain an initial constant COD loading. The net result is a system that eventually consists of all waste food. The ability of the bacteria to survive and/or metabolize the waste and the rate at which they will acclimatize to the waste are the desired results of the test.

The necessity of providing sufficient nourishment for the desired bio culture density on a 24 hour test cycle restricted the initial tests (Symons, et.al.) to an evaluation of plant wastes capable of supplying this minimal value (approximately 1,000 mg/day COD). These test restrictions limited the initial waste evaluations to the ammonium based materials (raw ammonia liquor and ammonia still waste). In the evaluation, a mixture of these two wastes was utilized with the blend ratio corresponding to possible plant effluent ratios.

The results of these tests indicated the following:

1. The by-product waste mixture was 70% reduced in chemical oxygen demand (COD). The removal mechanism was probably a combination of biological assimilation and mechanical air stripping.

2. The palm oil waste evaluated was completely metabolized (100% reduction) indicating excellent compatability with the biological culture(s).

Phase II

The purpose of this phase of the study was solely to establish compatability. For wastes containing less than the minimum 1,000 mg/day COD value required to support the bio culture, system modifications were required. These modifications made use of a supplemental food source of a known degradation rate added to the waste being investigated to provide the required minimum nutrient level. The

TABLE 13

BATCH PILOT UNIT - WASTE COMPOSITION

	Waste	Sodium Benzoate Base (1) And Added Waste Volume (in ml/day)
1.	Benzol CT Bleed	8
2.	Benzol CT Sump	100
3.	Final Cooler Bleed	60
4.	Ammonia Still Waste	120
5.	Raw Ammonia Liquor	120
6.	Absorber Baro. Cond.	1000
7.	Elliott Strainer Backwash	336
8.	Blank	-
*9.	Blank	-
10.	Raw Ammonia Liquor 4 x Normal Conc.	500

(1) Sodium benzoate added to each system in terms of 1000 mg COD/day or 362 mg TOC/day.

* In system (9) Sodium benzoate added as 2000 mg COD/day or 724 mg TOC/day.

food source selected was sodium benzoate. The test conditions employed in this phase utilized calculated additions of a specific waste which corresponded in most cases to a rate equal to twice the waste volume that would be encountered in actual plant operations. The wastes tested included raw ammonia liquor, ammonia still waste, barometric condenser effluent, benzol cooling tower bleed, final cooler bleed, benzol sump, and Elliott strainer backwash. These wastes were always supplemented with a fixed amount of sodium benzoate. Fresh sewage was utilized as a dilutant to obtain the desired system volume and as a source of trace nutrients. Since the total system BOD value was always greater than its base feed by some amount, two blanks were carried throughout the tests. The first blank or reference was restricted to a 1,000 ppm base rate. The second reference was carried at a considerably higher value to indicate the degree to which the biological system could accomodate the higher BOD values contributed by the wastes in the other test systems.

The objective of this series of tests was designed to show the effect of the various plant wastes on the degradation rate of the sodium benzoate through comparative analyses of the waste system and the sodium benzoate reference system. The analytical results utilized were based on the soluble TOC values taken at the termination of each 24 hour test period.

Correlation of the various system analyses with the sodium benzoate standard over an extended (11 day) period of time, as shown in Figures 17, 18, 19, 20, 21, 22, 23 and 24 would indicate the following conditions or trends.

1. Acclimatization

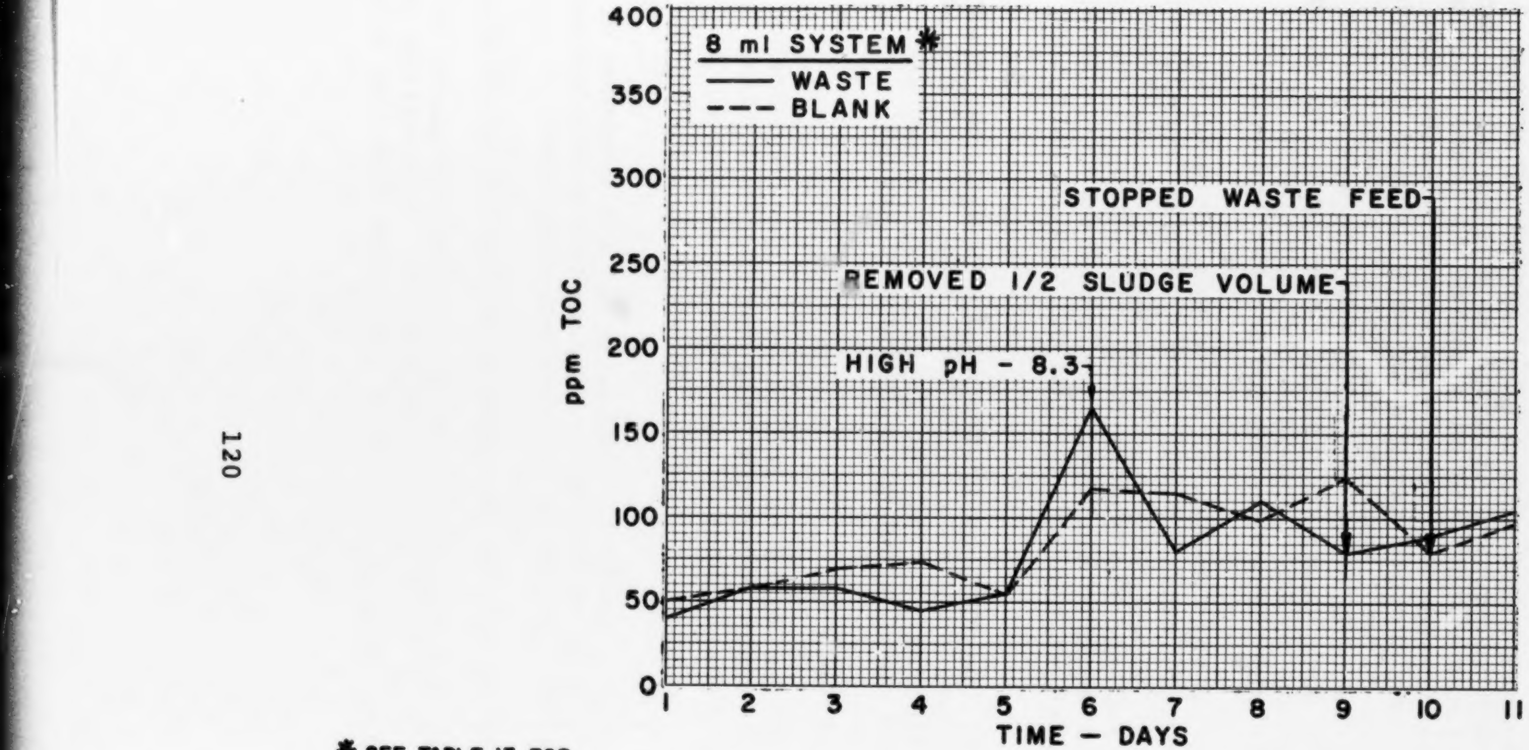
   This condition would be indicated by the convergence of the waste versus reference test results with time. This condition is best illustrated by Figure 20-21.

2. Toxicity

   This condition would be indicated by a divergence of the test result values with time. This condition was not indicated in any of the systems evaluated.

3. Inhibitory or slowly degradable/refractory waste materials

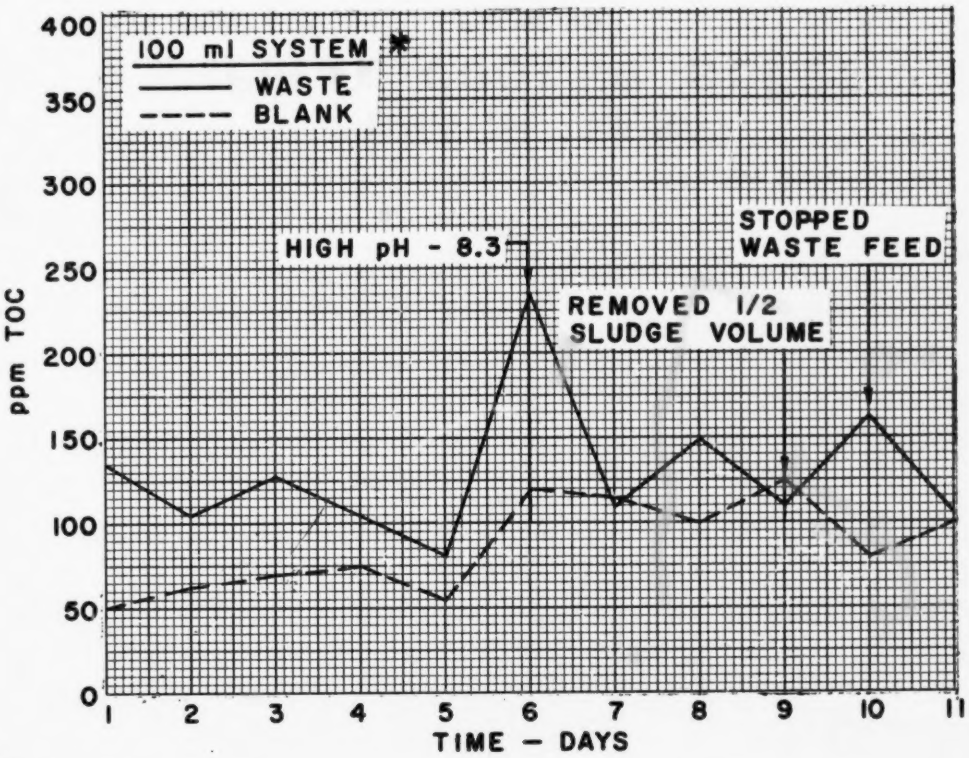
   This condition would be indicated by the presence of parallel data of different magnitude. Observation of the terminal sludge densities indicated that the high



* SEE TABLE 13 FOR WASTE COMPOSITION

BATCH TEST
BENZOL COOLING TOWER BLEED

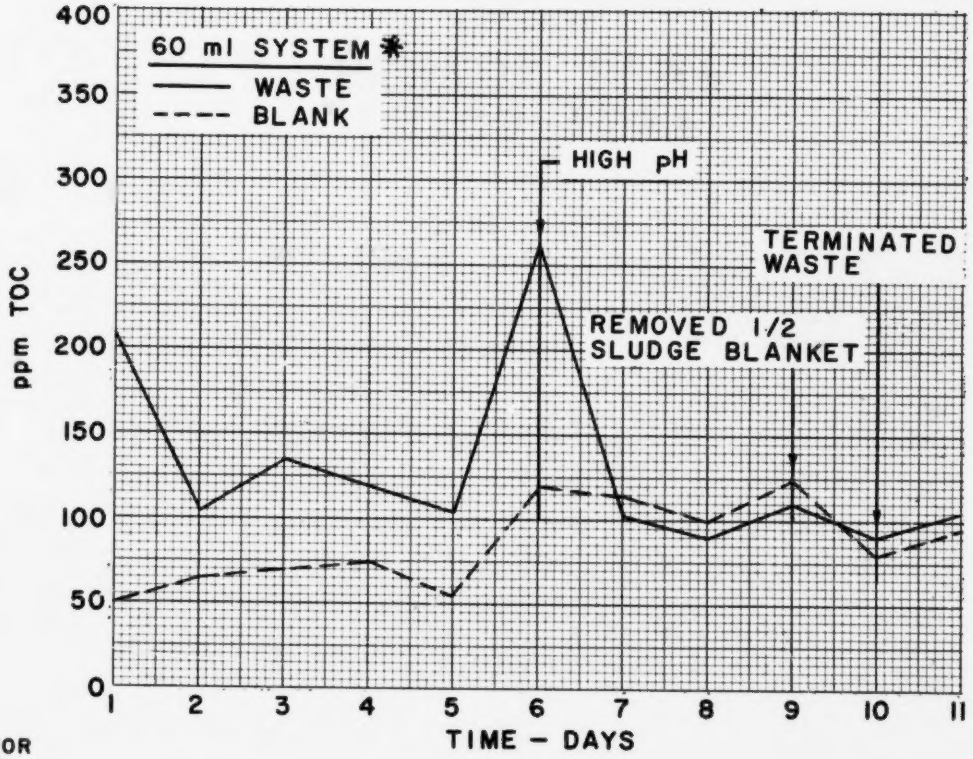
FIGURE 17



* SEE TABLE 13 FOR WASTE COMPOSITION

BATCH TEST
BENZOL SUMP

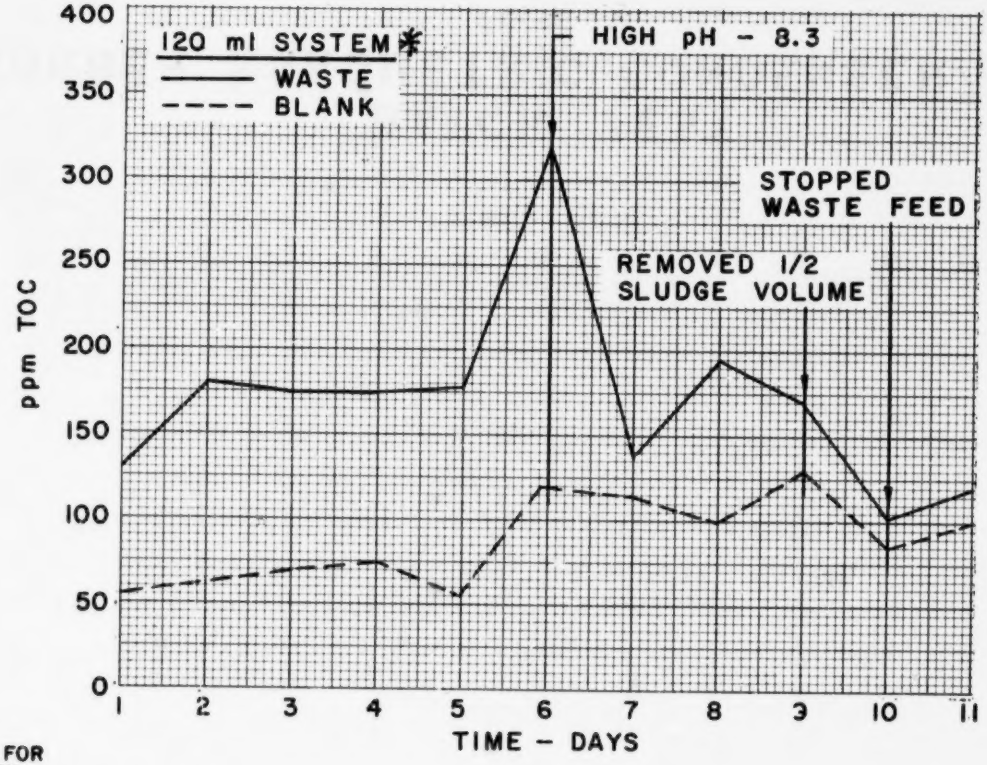
FIGURE 18



* SEE TABLE 13 FOR WASTE COMPOSITION

BATCH TEST
FINAL COOLER BLEED

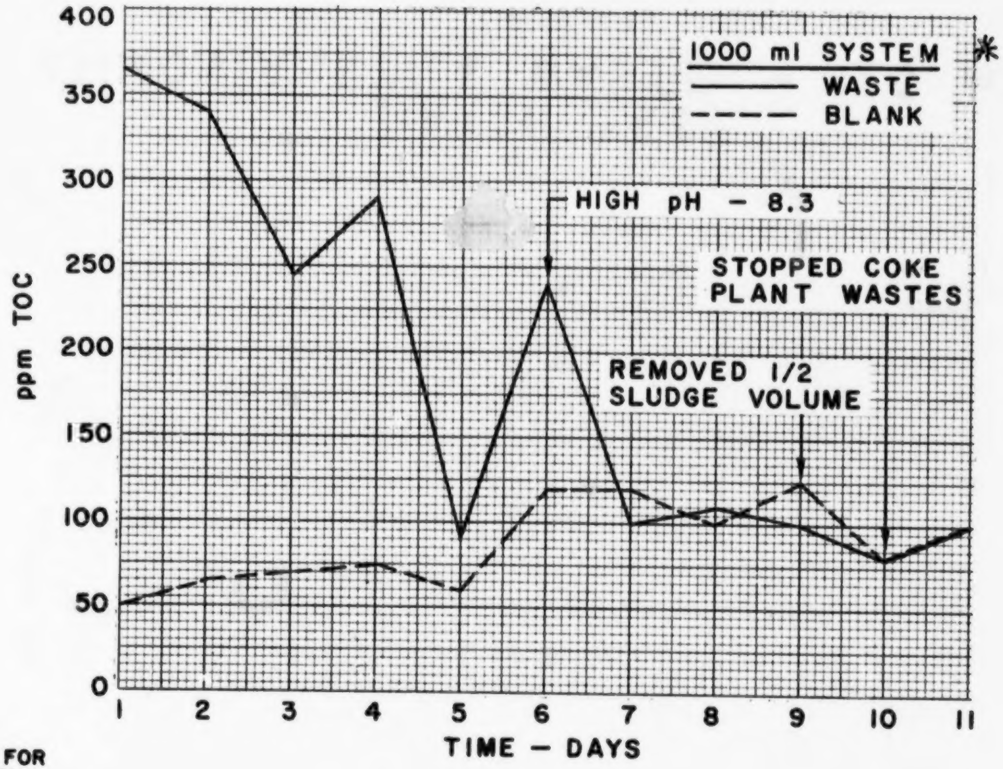
FIGURE 19



* SEE TABLE 13 FOR WASTE COMPOSITION

BATCH TEST
AMMONIA STILL WASTE – 120 ml

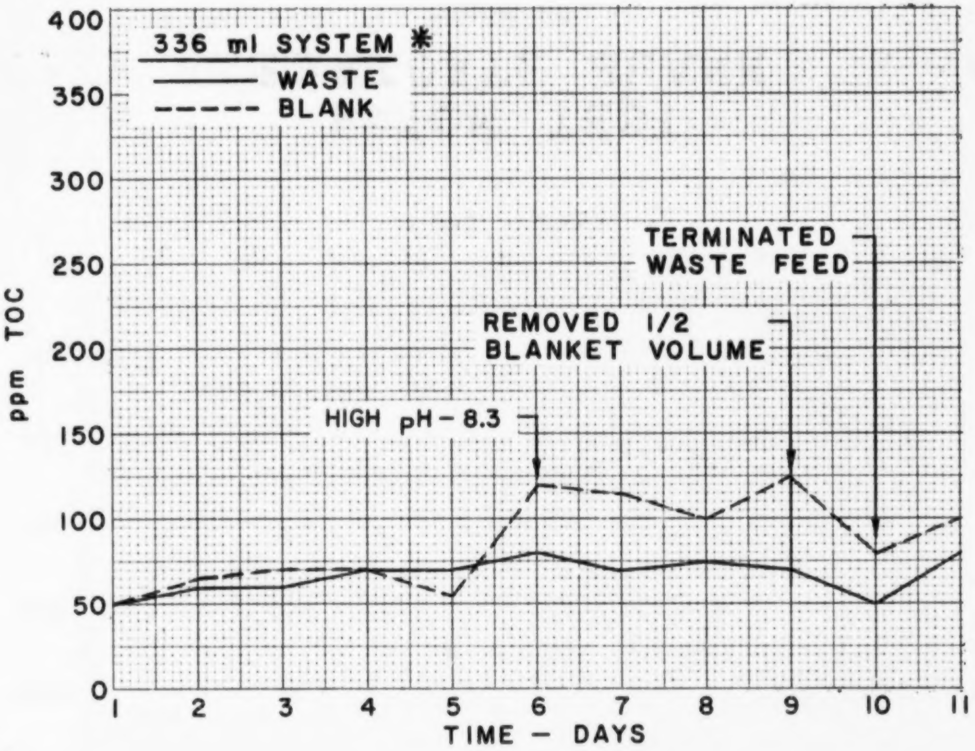
FIGURE 20



* SEE TABLE 13 FOR WASTE COMPOSITION

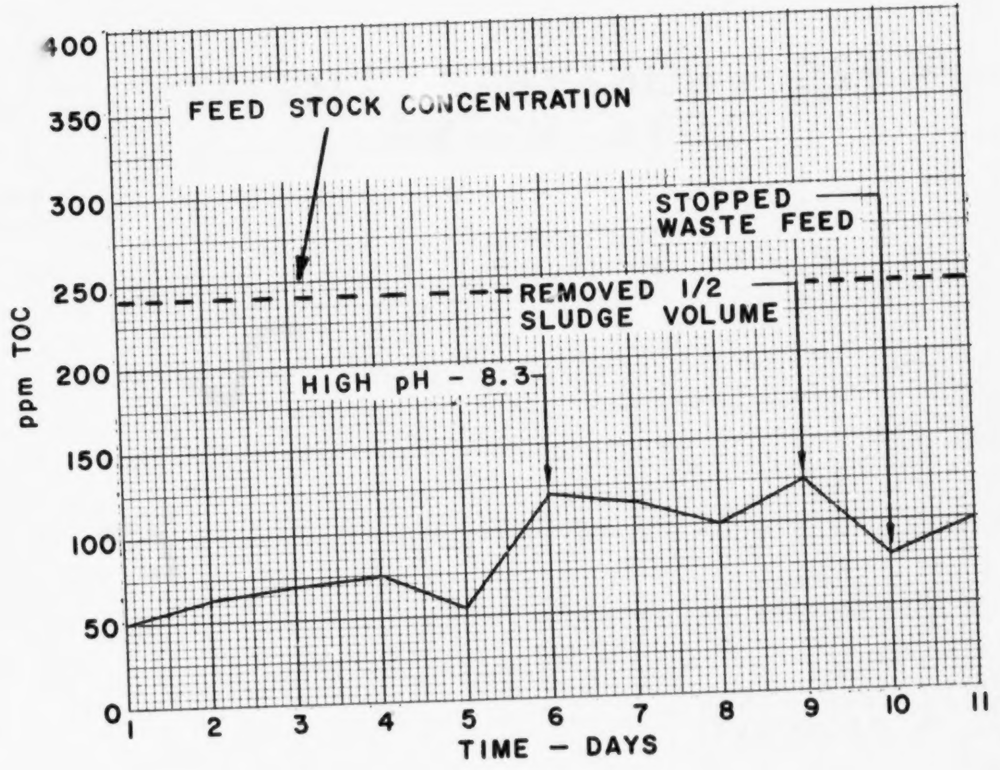
BATCH TEST
ABSORBER BAROMETRIC CONDENSER - 1000 ml

FIGURE 21



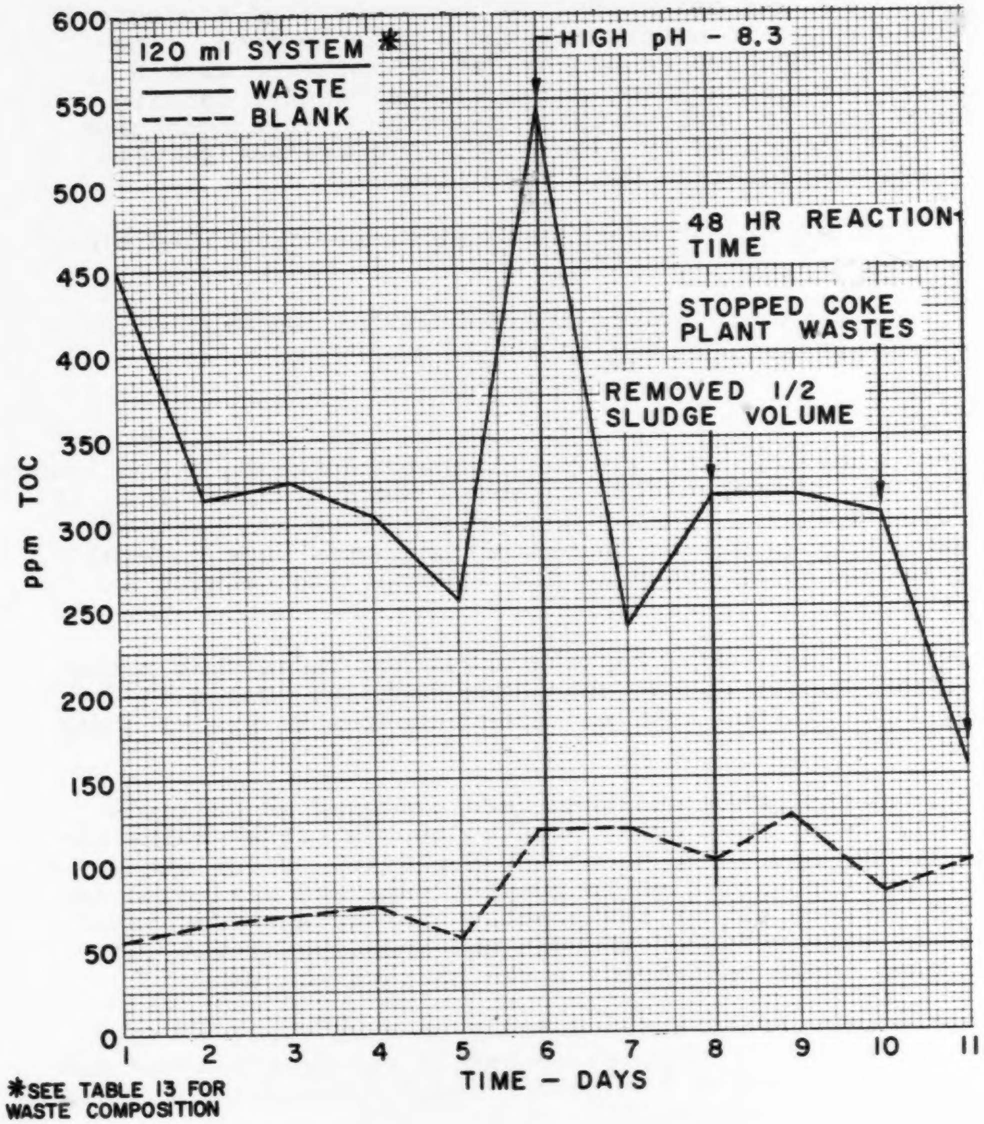
* SEE TABLE 13 FOR WASTE COMPOSITION

BATCH TEST
ELLIOTT STRAINER – 336 ml
FIGURE 22



BATCH TEST
BENZOATE BLANK

FIGURE 23



BATCH TEST
RAW AMMONIA LIQUOR

FIGURE 24

BOD levels was not conducive to accelerated biological growth rates to accomodate the available food. The minimum reduction in bio-oxidation incurred with a major (50%) reduction in the sludge blanket density would tend to confirm this condition. This condition is best indicated by Figure 24. Significant results of this test series were as follows:

1. Ammonia liquor wastes substantially inhibited biological assimilation.
2. All remaining wastes tested showed comparable assimilation rates with the blank.

Phase III

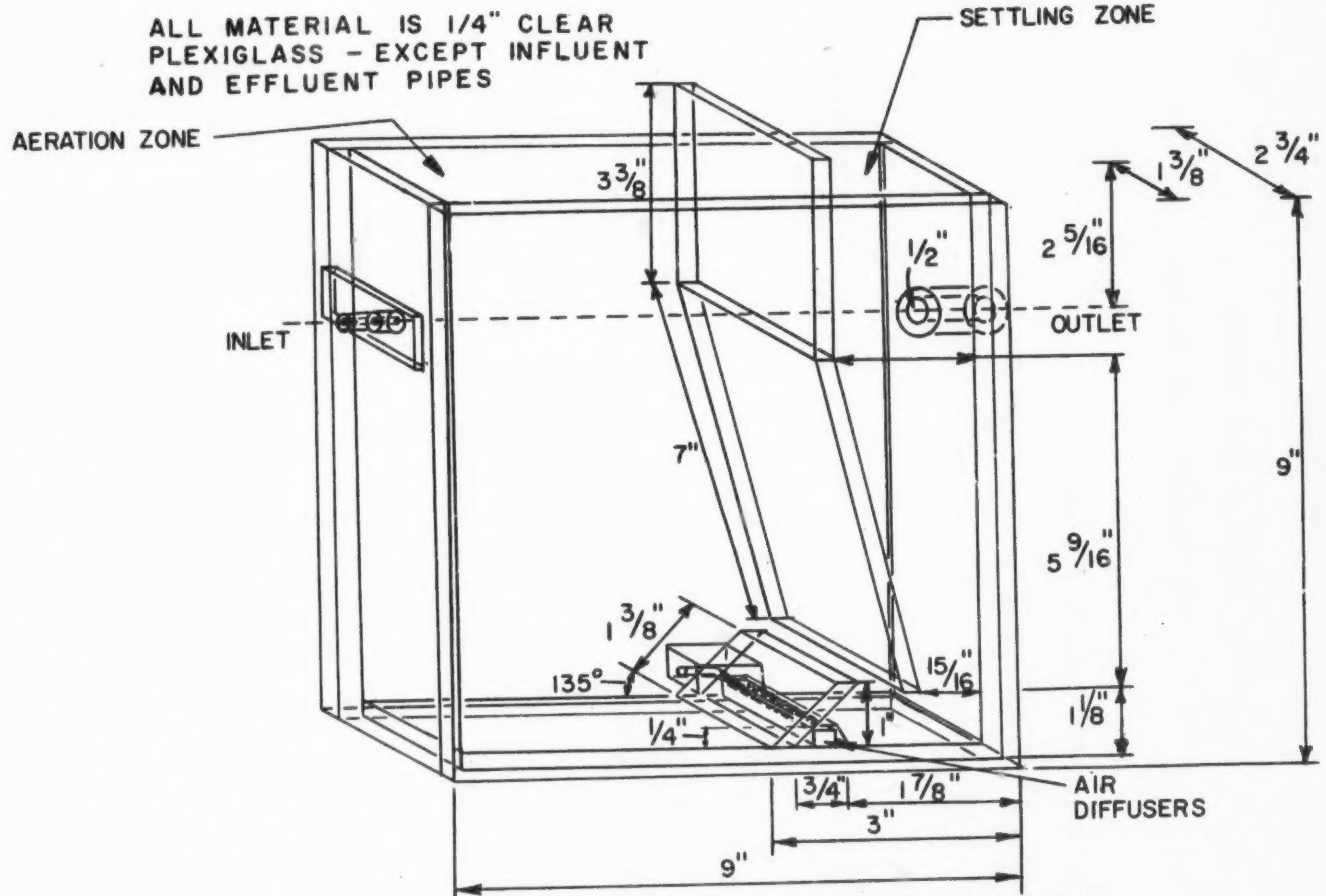
The final phase of the study was conducted using a continuous flow system. The apparatus in these tests utilized four (4) pilot continuous flow biological reactors in conjunction with two fully adjustable peristaltic pumps. The general configuration is as shown in the accompanying drawing (Figure 25).

These pilot plants were run at capacities reflecting proper scale down from an actual operating faciliy. Table 14 shows a typical feed rate and concentration to one of these pilot plants.

The peristaltic pumps utilized were employed as multiple head pumps, each pump being used to supply either waste or sewage to the operating bench scale plants. Under these conditions, any variation in pumping rate was reflected in the feed rate to all of the plants. Interplant feed rate variations were effected through the changing of the individual pump tubes contained in the particular pump.

Raw wastes were contained and fed from a multiple of five (5) gallon bottles. The sewage bottle was both aerated and refrigerated to retard biological decomposition and to keep it in an aerobic condition.

In the operation of these plants, the regulation of the air flow and baffle positioning was otpimized to provide a relatively fast rolling action in the aeration chamber. Excess air flow was utilized to insure adequate aeration. Sampling was performed at 24-hour intervals.



PILOT ACTIVATED SLUDGE TREATMENT PLANT
CONTINUOUS FLOW MODEL

FIGURE 25

TABLE 14

BENCH SCALE PLANT

CONTINUOUS FLOW MODEL

Total Capacity 2,000 ml/plant

Loading 815-1630 Kg/l/1000 m^3/24 hours

Feed Concentration 180-220 mg/l BOD

Loading of plant for this study based on 1200 Kg/1000 m^3

2.4 gms BOD/24 hours

at 200 mg/l BOD value = 8.35 ml/min.

4 hours retention time

A series of three (3) system tests were conducted in the continuous bench scale plants utilizing, in various ratios, all the plant wastes with the exception of the raw ammonia liquor and ammonia still wastes fraction from the coke plant waste stream. A fourth plant was put on-line utilizing the raw ammonia liquor and ammonia still waste. The computed blends for systems I through IV are shown in Tables 15, 17, 19, and 21, respectively. Tables 16, 18, 20, 22, and Figures 26, 27 and 28 reflect the results of these tests.

Specifically, the results of these studies show the following:

1. Input TOC loadings varied widely, but removal effiencies remained relatively constant.
2. On a continuous basis, TOC removal ranged between 50% and 70% based on an approximate detention time of 3.7 hours.
3. Slime bacteria were noted to exist in all four (4) of the continuous pilot units tested and was predominant in System II, which consisted primarily of benzol final cooler bleed and absorber barometric condenser wastes.
4. No apparent acute toxicity problems were encountered in any of the systems tested.

TABLE 15

SYSTEM I

COMPUTED BLENDS*

	ml
Benzol Cooling Tower Bleed	35
Benzol Cooling Tower Sump	600
Final Cooler Bleed	365
Absorber Barometric Cond.	825
Elliott Strainer Backwash	2000
Palm Oil	5000
Weirlite	350
Detinning	350
Tin Mill	350
Galvanizing Mill	70
N&S Scrubber	(**)
Batch Total Volume	9945

* Blends derived from proposed alternate piping arrangements.

** Scrubber volume varied daily to effect proper pH control.

TABLE 16

SYSTEM NO. 1

PLANT PERFORMANCE

Day	Raw Sewage TOC	Raw* Waste TOC	Combined Influent TOC	Effluent TOC	% Reduction	Retention Time Hours	pH
1.	42	114	83	48	40	9.8	7.7
2.	42	114	83	52	37	9.8	7.6
3.	57	40	48	31	35	16.6	7.7
4.	25	52	38	19	50	16.6	-
5.	109	99	104	19	81	16.6	7.7
6.	88	81	79	25	69	3.6	-
7.	47	120	76	17	59	3.6	7.0
8.	66	111	93	23	75	3.6	7.1
9.	51	125	95	50	47	3.6	8.2
10.	91	345	230	62	73	3.8	7.3
11.	50	177	125	36	71	3.8	6.7
12.	77	128	110	24	78	3.8	6.7
13.	62	145	112	34	69	3.8	-
14.	81	119	107	27	75	3.8	6.4
15.	64	240	168	70	58	3.8	8.0

*See Table 26 for composition of raw waste

TABLE 17

SYSTEM II

COMPUTED BLENDS*

	ml
Benzol Cooling Tower Bleed	31
Benzol Cooling Tower Sump	530
Final Cooler Bleed	360
Absorber Barometric Condenser	7400
Elliott Strainer Backwash	1800
N&S Scrubber	(**)
TOTAL	10121

* Blends derived from proposed alternate piping arrangements.

** Scrubber volume varied daily to effect proper pH control.

TABLE 18

SYSTEM II

PLANT PERFORMANCE

Day	Raw Sewage TOC	Raw* Waste TOC	Combined Influent TOC	Effluent TOC	% Reduction	Retention Time Hours	pH
1.	42	82	62	33	47	9.8	7.5
2.	42	82	62	42	32	9.8	7.5
3.	57	86	77	30	61	8.3	7.5
4.	25	98	61	18	70	8.3	-
5.	109	82	95	30	69	8.3	7.5
6.	88	77	81	33	60	8.3	-
7.	47	129	79	109	(-30)	3.6	7.0
8.	66	112	94	74	21	3.6	6.9
9.	51	125	88	83	6	3.6	6.9
10.	91	160	128	49	61	3.8	7.0
11.	50	172	123	50	59	3.8	6.7
12.	77	178	138	118	14	3.8	6.9
13.	62	141	110	48	56	3.8	-
14.	81	169	135	35	74	3.8	6.9
15.	64	152	117	40	66	3.8	6.8

*See Table 29 for composition of raw waste

TABLE 19

SYSTEM III

COMPUTED BLENDS*

	ml
Benzol Cooling Tower Bleed	41
Benzol Cooling Tower Sump	700
Final Cooler Bleed	43
Absorber Barometric Condenser	970
Elliott Strainer Backwash	2380
Palm Oil	5580
N&S Scrubber	(**)
TOTAL	10094

* Blends derived from proposed alternate piping arrangements.

** Scrubber volume varied daily to effect proper pH control.

TABLE 20

SYSTEM NO. III

PLANT PERFORMANCE

Day	Raw Sewage TOC	Raw* Waste TOC	Combined Influent TOC	Effluent TOC	% Reduction	Retention Time Hours	pH
1.	42	135	95	33	65	9.8	7.3
2.	42	135	95	47	50	9.8	7.3
3.	57	75	66	34	49	16.6	7.3
4.	25	88	56	29	48	16.6	-
5.	109	158	133	21	84	16.6	7.5
6.	88	81	85	16	81	16.6	-
7.	47	124	77	36	41	3.6	6.9
8.	66	132	105	27	74	3.6	6.8
9.	51	167	120	70	42	3.6	6.9
10.	91	465	295	129	56	3.8	6.7
11.	50	257	172	30	82	3.8	6.7
12.	77	223	164	96	41	3.8	7.0
13.	62	222	156	62	60	3.8	-
14.	81	209	159	45	72	3.8	6.9
15.	64	174	130	51	61	3.8	6.8

*See Table 32 for composition of raw waste

TABLE 21

SYSTEM IV

COMPUTED BLENDS*

	ml
Raw Ammonia Liquor	784
Ammonia Still Waste	784
Benzol Cooling Tower Bleed	37
Benzol Cooling Tower Sump	635
Final Cooler Bleed	370
Absorber Barometric Condenser	875
Palm Oil	5300
Weirlite Line	370
Detinning	370
Tin Mill	370
Sheet Mill	74
N&S Scrubber	(**)
Total	9964

* Blends derived from proposed alternate piping arrangements.

** Scrubber volume varied daily to effect proper pH control.

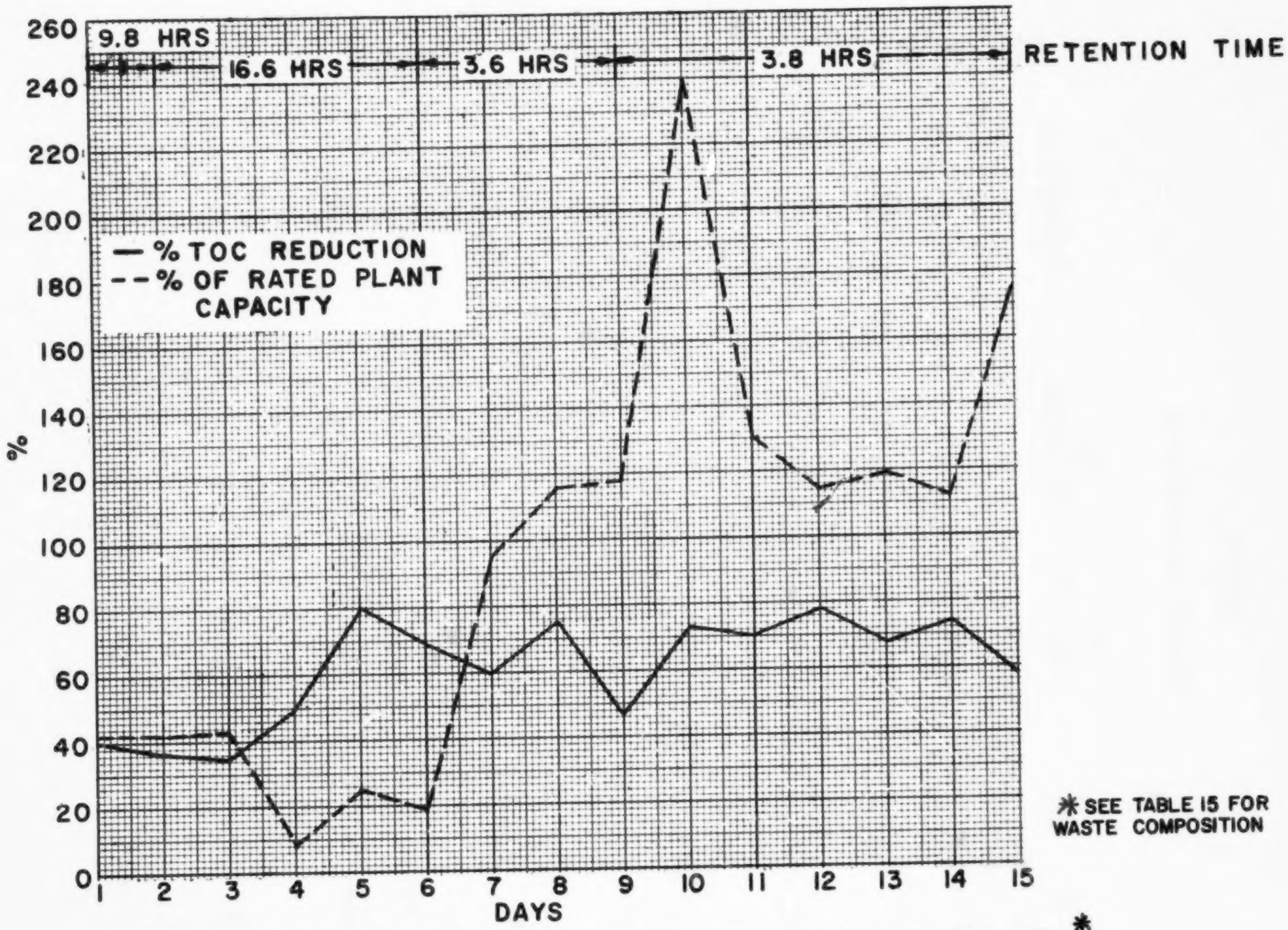
TABLE 22

SYSTEM IV

PLANT PERFORMANCE

1st Day	TOC Influent	TOC Effluent	% Reduction
Sewage	90		
Waste Feed*	360		
Combined	232	165	33
2nd Day			
Sewage	50		
Waste Feed*	190		
Combined	126	102	20
3rd Day			
Sewage	78		
Waste Feed*	294		
Combined	193	112	40
4th Day			
Sewage	64		
Waste Feed*	209		
Combined	151	74	51
5th Day			
Sewage	56		
Waste Feed*	189		
Combined	127	38	71

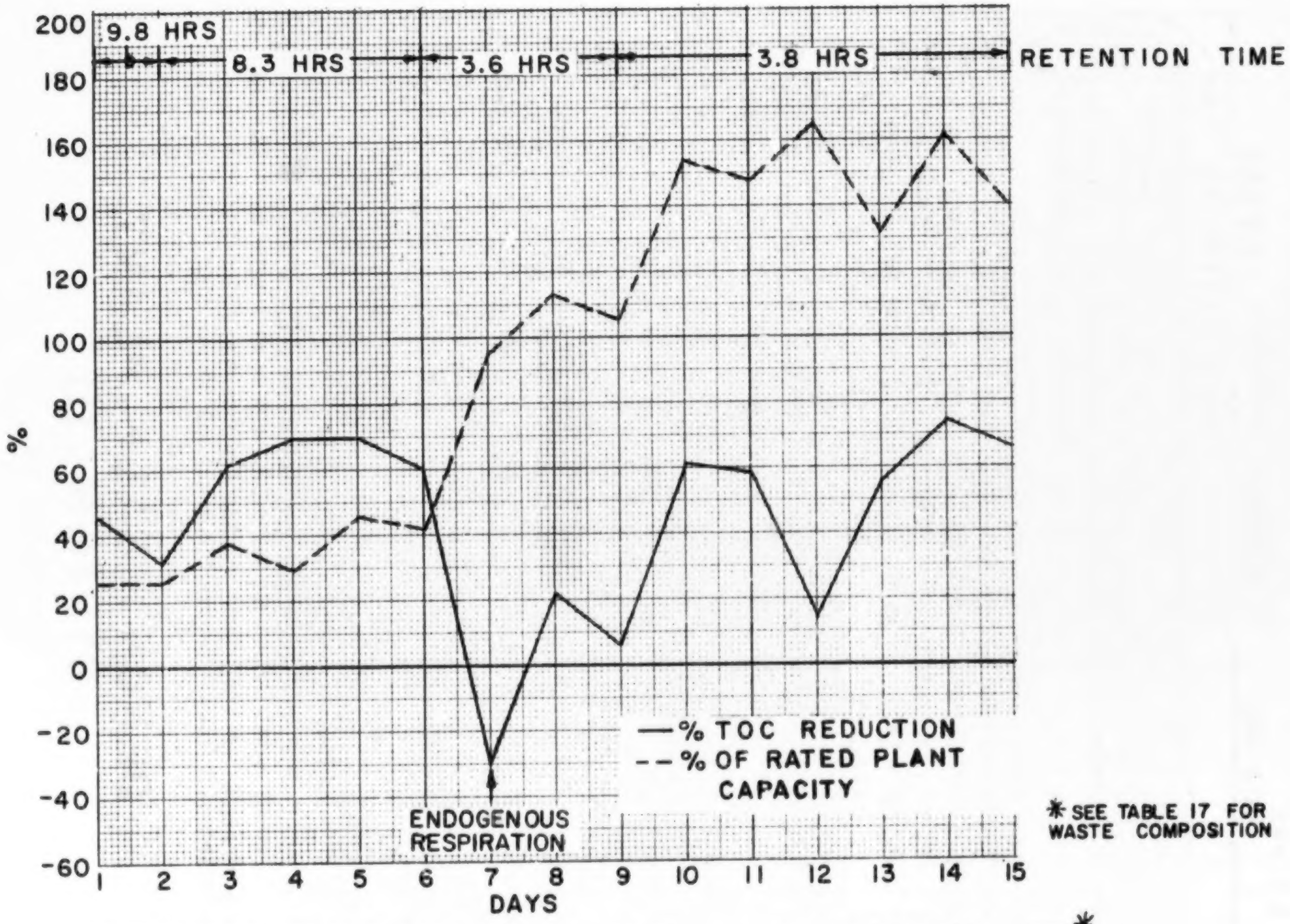
* See Table 35 for composition of raw waste.



* SEE TABLE 15 FOR WASTE COMPOSITION

BENCH SCALE PLANT — SYSTEM I*

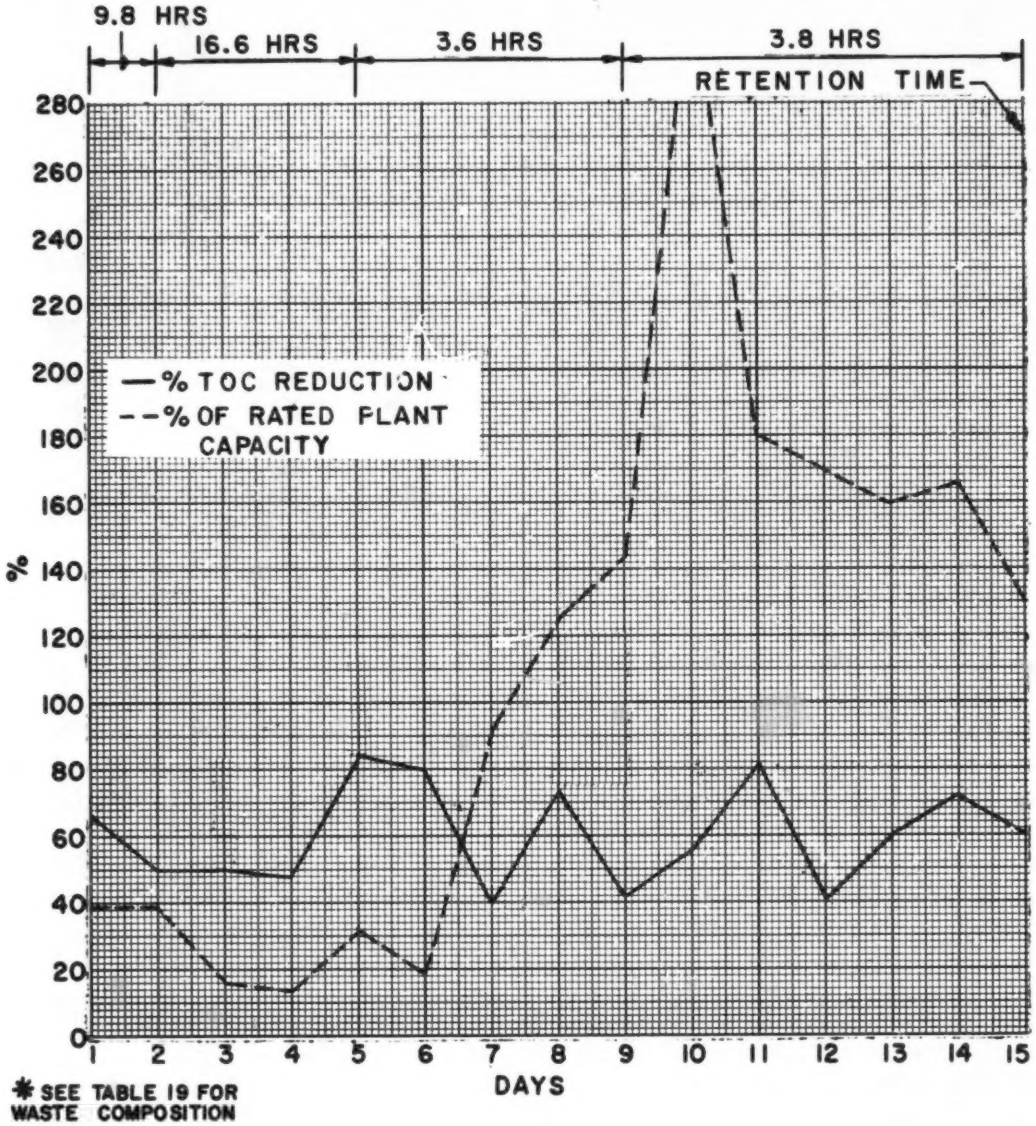
FIGURE 26



* SEE TABLE 17 FOR WASTE COMPOSITION

BENCH SCALE PLANT - SYSTEM II*

FIGURE 27



BENCH SCALE PLANT SYSTEM III*

FIGURE 28

GENERAL CONCLUSIONS

PHASES I, II & III

1. All waste combinations were found to be amenable to biological acclimation.

2. In the concentrations used in the test work, the raw ammonia liquor and the ammonia still wastes fraction of the coke plant wastes displayed the most inhibition on biological activity. Extended reaction times were indicated for those wastes to effect more complete removals.

3. The other waste combinations tested showed relatively good biological activity and resultant degradation (50% - 70% TOC reduction).

4. The potential conversion of the biological cultures to the slime variety as encountered in these studies may cause problems in the design of an activated sludge plant.

5. "Healthy" operation of the various pilot plants required a high rate of sludge wasting thus indicating possible adsorption of toxic materials on the bacteria.

6. A high concentration of readily degradable food (palm oil) was required for stable operation of the pilot plants.

7. Considerably more work is indicated with a much larger demonstration plant to provide data for the optimization of the wastes encountered in this situation. Due to the nature of these wastes, the work should be performed at the actual site to provide the quantities of fresh wastes required. The work to be performed would be aimed at the optimization of waste blending, pH, temperature, nutrient requirements, etc., in an attempt to achieve healthy, stable operations and acceptable removal efficiencies.

SECTION XI

RIVER WATER QUALITY ASSESSMENT

The project has included a study of the State water quality criteria stated below for maintaining water quality criteria in the main stem of the Ohio River. This criteria is a part of the West Virginia administrative regulations on water quality criteria on inter and intra state streams as developed under the guidance of the Division of Water Resources:

	Parameter	Ohio River	Tributaries
1.	Dissolved oxygen	Not less than 5 mg/l at any time	Same
2.	pH	5.5 - 9.0	6.0 - 8.5
3.	Temperature	Not to exceed 87°F May to November - not to exceed 73°F Dec. to April	Same
4.	Threshold	Not to exceed 24 at 60°F as a daily average	Not to exceed 8 at 60°C
5.	Toxic substances	Not to exceed 1/10 of the 48 hr. medium tolerance limit	Not to exceed 1/10 of the 96 hr. medium tolerance limit
6.	Bacteria	Coliform group is not to exceed 1,000 per 100 ml as a monthly average - not to exceed 2,000 per 100 ml for 5% of the samples	Same

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7. Heavy Metals: Not to exceed the following:

Constituent	Ohio River	Tributaries
Arsenic	0.01 mg/l	Same
Barium	0.50 mg/l	Same
Cadmium	0.01 mg/l	Same
Chromium (hexavalent)	0.05 mg/l	Same
Lead	0.05 mg/l	Same
Silver	0.05 mg/l	Same

8.

Constituent	Ohio River	Tributaries
Nitrates	45.0 mg/l	Same
Phenol	0.001 mg/l	
Cyanides	0.025 mg/l	
Fluorides	1.00 mg/l	
Selenium	0.01 mg/l	
Chlorides	None	100 mg/l
Sulfates	None	200 mg/l

An evaluation was made of a limited quantity of Ohio River analytical data over the past five (5) years at points above and below Weirton. Prime consideration was given to parameters that are a source of potential discharges in the stretch of the river between Weirton and Wheeling. These included zinc, aluminum, phenols, sulfates, copper, color, chlorides, chromium, manganese, iron alkalinity, hardness and lead. The following table indicates the average composite of various parameters in this section of the river.

Parameter	Average, ppm
Zinc, Dissolved	0.027
Aluminum, Dissolved	0.193
Phenols	0.004
Sulfates	208.000
Color, Units	8.400
Chlorides	25.400
Total Hardness, ppm $CaCO_3$	181.500
Manganese	0.127
pH	6.600
Total Iron	0.428
Total Alkalinity, ppm $CaCO_3$	13.000
Lead, Dissolved	0.025
D. O.	8.300

With this sparse data and the extreme flow rate of the stream it is impossible to accurately predict the changes that would occur as a result of the construction of a joint municipal industrial sewage treatment plant.

Section XII

Demonstration Plant Feasibility Determination

Considering the need of the City of Weirton for secondary sewage treatment in the near future, the logistics and capacities of the present sewers and treatment plant, the nature and volumes of wastewater streams from the mill, and the treatability of combined mill wastes and sanitary sewage, it is concluded that a demonstration plant is feasible and would be economically justified.

The laboratory studies indicate that the required additional facilities of the sewage treatment would not be substantially different with or without the addition of the mill wastes, although additional instrumentation and controls would be necessary. The unused capacity of the sewage treatment plant presently constitutes a non-productive investment, as does the unused capacity of the sewer system. These factors alone probably justify the use of joint treatment.

Various alternatives were evaluated in arriving at a feasible cotreatment scheme. At the sewage treatment, consideration was given to the following: 1) the use of present primary plant in its present state with the effluent being discharged to a secondary plant at the steel mill, 2) construction of a secondary plant at the site of the present primary sewage plant. At the steel plant the following points were considered: 1) volume and type of wastes to be treated, 2) location of the treatment plant and 3) methods of transporting the wastes to the treatment plant.

A study of these alternatives produced the following general conclusions:

1. Based on a representative number of steel plants in the United States, the ratio of the magnitude of the overall waste volume of an integrated steel plant to the volume of municipal wastes would be in the order of about 50 to 1.

2. Pretreatment of these same steel plant wastes and/or including only concentrated waste streams would reduce the forementioned ratio to a factor of approximately 10 to 1.

3. Sanitary design practice recommends a 250% safety factor for sanitary sewer design. Therefore, this limits the volume of wastes that can be transported in existing sewers. The

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construction of additional sewer lines has several drawbacks which include: a) excessive costs, b) legal and political red tape involved in securing permission for the right of ways, etc., c) safety hazards and general inconvenience to the steel plant and the local populace before and during construction. A new installation might have similar shortcomings although the intangible ramifications may not be as severe. However, the sewer line costs would be appreciably higher for the considerably larger sewer size. Handling and installation costs rise appreciably with increase in size.

4. The other principal method for waste transport would be hauling. Here again the costs for hauling would be excessive. Generally hauling of this type is on a cost per gallon basis and truck capacity is about 5,000 gallons. Therefore, this would require many trucks on an around the clock basis to handle any appreciable volume.

5. The alternative separate treatment of mill wastes within the plant would necessitate the installation of all of the equipment required under the recommended joint treatment scheme, plus an activated sludge or trickling filter unit at the coke plant which would be at least as expensive as the proposed secondary unit at the sewage treatment plant. Space limitations at the coke plant would make such an installation difficult, while adequate space is easily available at the sewage treatment plant.

With a review of these conclusions the study was conducted on the basis that only a limited volume of wastes could be treated in the average cotreatment venture with steel plant and municipal wastes.

The treatability studies have indicated that joint treatment is feasible, but does require more close control than would a conventional sewage treatment plant. The available mill wastes provide the required additional biological food supply (palm oil recovery plant) and the acid needed for pH control (pickling line scrubbers). The treatability studies have also shown that difficult-to-treat coke plant wastes and a limited volume of chemical wastes i.e., tin mill, galvanizing mill, and alkaline cleaning wastes can also be disposed of in such a system.

Treatability studies alone cannot answer the question of feasibility. The relative volumes of the wastewater streams and the logistics of the overall situation impose the limiting conditions, once treatability has been established. The present study has shown that these three factors can be satisfactorily integrated in an overall treatment scheme. It must be remembered that the really unique feature of the proposed scheme is that the municipal waste volume is only about one-fourth that of the total wastes treated. Similar wastes have previously been co-treated in municipal plants where these wastes are only a small percentage of the total.

The proposed demonstration plant is justified because, although the basic technology has been defined, specific operating procedures must be developed. The needs for sludge concentration control, pH control, and control of the relative rates of waste additions require that initial design and operation be much more flexible than would normally be required in a wastewater treatment plant. Such a situation is, by definition, one which calls for a demonstration project, i.e., technical feasibility has been shown, but design and operating details remain to be elucidated before the process scheme can be routinely implemented in similar situations.

Treatment costs

The mill wastes which would go to the municipal plant for treatment under the proposed joint treatment system are as follows:

1. Coke plant wastewaters	
a. Absorber barometric condenser waters	
b. Benzol sump overflow	
c. Ammonia still waste	
d. Final cooler bleedoff	
e. Benzol cooling tower bleed	2.0 mgd
2. Palm oil recovery effluent	1.0 mgd
3. Alkaline cleaning solutions, scrubber rinses, chromic reduction wastes, weirlite mill effluent, galvanizing line overflows	0.3 mgd

Based upon an assumed steelmaking capacity of 3.5 million ingot tons per year and a unit cost of 20¢ per annual ingot ton, the construction costs for in-plant biological treatment of coke plant wastes are estimated at $700,000 on the average. These estimates compare favorably with construction costs referenced by the water quality office of EPA and the U. S. Department of Health, Education and Welfare.

Assuming that these costs in an older mill which is crowded and required relocation of equipment are 135% of the average, the costs involved at Weirton Steel could increase to $945,000. The construction costs for in-plant treatment of the chemical-type wastes are estimated at $500,000.

Capital expenditures and operating costs for in-plant treatment of the same waste volume that are candidates for the combined treatment plant would be as follows:

	Capital expenditures	Annual oper. costs
Coke plant wastewaters	$ 850,000*	$100,000
Secondary palm oil treatment	--**	100,000
Weirlite mill secondary treatment	--**	25,000
Tin plating wastes	150,000	50,000

* Average between estimated new construction costs and costs for older mill

** Already installed

	Capital expenditures	Annual oper. costs
Galvanizing line overflows	$ 100,000	$ 35,000
Tin mill cleaning lines	50,000	10,000
Scrubber rinses	250,000	75,000
Total	$1,400,000	$395,000

The joint treatment system proposed would require in-plant piping changes, facilities for holding tanks, metering pumps, and instrumentation. The costs of such facilities should be investigated and their merits evaluated by the steel plant. In-plant operating and maintenance costs would be nominal, probably about 10¢ per 1,000 gallons, or about $330 per day. The joint treatment system proposed would thus reduce the total investment required by about one million dollars and save about $275,000 per year in operating and maintenance costs. Additional economics would be realized in that the wastewater treatment operations would be largely outside of the plant, resulting in minimum interference with production operations in both space and manpower requirements.

Insofar as the sewage treatment plant is concerned, the costs involved in the joint treatment system would not be significantly greater than for the addition of secondary treatment. It is probable that joint treatment would result in better overall performance than would be realized from secondary treatment of the municipal wastes alone so long as adequate precautions are taken to guard against slug discharges of the industrial wastes. The treatability studies indicate that the anticipated synergistic effects of the industrial wastes are, in fact, realized, although quantitative results were inconsistent. Further operating advantages can probably be realized due to the fact that the organic loading on the secondary unit would be higher and more consistent under the joint treatment system than would be the case with municipal wastes alone.

Recommendations have been made for conservation and reuse measures at the blast furnaces and the hot strip mill which would reduce these wastewater volumes and would increase the degree of treatment attained. The improved treatment efficiency is attainable by virtue of the reduced hydraulic loadings and on account of the agglomeration tendencies normally experienced in recirculating systems. It has also been suggested that magnetic agglomeration or polyelectrolytes be used on the B.O.P. and blast furnace thickener influents to improve sedimentation efficiency and thus reduce the suspended solids content of the blowdown stream from these recirculation systems. The other wastewater treatment methods suggested primarily concern operating practices and would involve minimal installation costs. In total, the costs of these suggested measures would probably not exceed 30¢ per ingot ton, or about one million dollars. It is thus suggested that an investment of the amount which would be required for the in-plant treatment of only the coke plant and chemical wastewaters could, utilizing the proposed joint treatment system, accomplish a satisfactory reduction of all significant wastes from the mill.

The economics of the proposed system would also seem to justify the demonstration plant which has otherwise been shown to be technically feasible.

Section XIII

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Section XIV

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A systems evaluation was made to determine the feasibility and economics of treating selected steel mill and sanitary wastewaters in a municipal sewage treatment plant. The project was Phase I of a three phase program to demonstrate that industry and municipalities through cooperative action can combine their wastewaters and attain their individual treatment goals in an efficient and economical manner.

Detailed field work was carried out at the steel plant and that total sewage plant treatment system. Selected steel plant wastes were combined with municipal wastes and evaluated in both batch and continuous treatability bench scale studies.

The investigation revealed that it is technically ane economically feasible to co-treat selected steel plant wastes with municipal wastewaters. A demonstration plant would further develop the specific operating procedures such as sludge concentration control, pH control, and rates of waste additions so that the process scheme could be routinely implemented in similar situations.

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